REPORT ON THE WORKING OF AMERICAN RAILWAYS.

By Lieutenant-Colonel W. V. Constable, R.E.

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Introductory Remarks.

1. Upon arrival in New York I spent a week there in order to attend the Semi-Annual Meeting of the American Railway Association and be present at their Bi-Annual Guild Dinner. Whilst there I inspected the New York Central and Hudson River Railway terminus (N. Y. C. and H. R. R.), as also the terminus and freight depôts of the Pennsylvania Railway (P. R. R.) at Jersey City, and I made the acquaintance of many of the chief operating officials of the railways of America. I then went over the Pennsylvania Railway (P. R. R.) as far as Pittsburg and inspected some 60 miles of their track around that city by special train. After spending half-a-day at the Pittsburg Pressed Steel Car Works, I went on to Chicago by the P. R. R. I stayed there a few days and inspected the Illinois Central Railway's workshop (I. C. R. R.), some of the Chicago termini, and a suburban railway, and then I went on to Salt Lake City by the Chicago and North-Western (C. and N. W. R. R.) and Union Pacific Railways (U. P. R. R.).

2. From Salt Lake City I went over the Denver and Rio Grande Railway (D. and R. G. R. R.) to Denver, and from the latter place I travelled by the Burlington Missouri Section of the Burlington Quincy Railway (B. Q. R. R.) to St. Louis, where I passed many hours in seeing the splendid Union station and the railway works around that town. From there I returned to Chicago by the Wabash Railway (W. R. R.), and after inspecting the Rock Island and Pacific Railway's workshops (R. I. and P. R. R.) I travelled by the Lake Shore Limited (L. S. R. R.) to Buffalo. There I visited the Pan-American Exhibition and went to Niagara, travelled on several fast suburban electric tramways and also saw one of the largest electric power plants, and from Buffalo I journeyed on to New York by the N. Y. C. R. R.

3. From the latter city, after inspecting the terminus and the freight depôts of the Central Railway of New Jersey (C. R. R. of N. J.), which is also one of the termini of the Baltimore and Ohio Railway (B. & O. R. R.), I proceeded to Baltimore by the B. & O. Royal Blue Limited. At Baltimore I inspected the B. & O. R. R.'s head workshops and their electric railway, as also their railway stations, freight depôts, harbour coal-loading and grain elevator plants. I also made a trip to Washington and back and went to Mount Vernon by an electric railway.

4. From Baltimore I proceeded to Pittsburg by the B. & O. R. R., having a good view of their mountain track which possesses many miles of grades 117 ft. to the mile, and went on to Cleveland by the P. R. R. to inspect the shipping of coal at the lakes. From there I visited Altoona, seeing their mountain route by daylight, and went over the P. R. R. workshops at the latter place. I then saw the P. R. R. track between Altoona and Philadelphia and stayed a day at the latter city seeing the terminus and some of the freight depôts and yards of the P. R. R. at that place. From Baltimore I returned to New York, and through the courtesy of the officials of the N. Y. C. & H. R. R. was taken by special train 40 miles northward from New York and back to see their road.

5. I then inspected the New York, New Haven, and Hartford Railway (N. Y. N. H. & H. R. R.) between New York and Boston, went over the fine stations at Boston and travelled by special train over a short branch of electric railways belonging to the N. Y. N. H. & H. R. R., and afterwards visited the Boston and Albany Workshops (B. & A. R. R.) at Allston near Boston. From there I went over the B. & A. R. R. to Albany and thence proceeded by a special train to the Locomotive as also the General Electric Works at Schenectady, and back to Albany. From the latter place I went back to New York by the N. Y. C. & H. R. R., and on to Baltimore by the B. & O. R. R., and returned to New York in time to sail for England on the 13th June.

General Classification of Railways I visited.

6. Those I saw may be divided roughly into two classes. The first comprises the P. R. R. East of Pittsburg; the N. Y. C. & H. R. R. proper; the N. Y. N. H. & H. R. R.; the B. & A. R. R., and the B. & O. R. R., between Jersey City and Washington, and they are equal to first class Indian roads, such as the old trunk lines uniting Madras, Bombay and Calcutta. They are even better as regards the smoothness of their track owing to their mostly having a 100 lb. rail and a very high proportion of sleepers, and the P. R. R. East of Pittsburg and a portion of the N. Y. C. R. R. proper may be classed with the best English lines. They are, however, not so finished as the best Indian roads in such matters as neat and substantial fencing, over- and under- bridges, station buildings and conveniences, platforms, etc. On the busiest portion, however, they are much better worked, and are ahead of the English railways, in so much as they are provided with automatic block working installations, and their termini and important stations have their points and signals interlocked and worked by electricity or air pressure or by a combination of both. Their principal termini, moreover, are very up-to-date, and most of their small stations on the Eastern Roads are interlocked mechanically. They are also much better equipped for taking coal and water on board expeditiously. These roads in the first classification, including the B. & O. Eastward of Grafton, are double track lines, the P. R. R. East of Pittsburg and the N. Y. C. East of Buffalo being four-track roads. The rest of the roads I saw, though of course some are better than others, are those which centre mostly on St. Louis and Chicago, and they get less and less finished as one goes West. All of these, excepting the C. and N. W. trunk line, are single track lines, and very few of them have rails heavier than 75 to 85 lbs. Their banks and cuttings are ragged, and their ballast is scanty in quantity and poor in quality, consisting chiefly of grit, ashes, slag, sand, granite, stone, or burnt clay. Many of their bridges and culverts are still wooden, in many cases girders and trestles both being of wood, and they have few over- and under- bridges, poor fencing, wretched stations, no proper drainage in cuttings, and in many cases no signals other than a "Stop" or "Proceed" board fixed to the station building. Where traffic is heavy, however, they suddenly go to the other extreme, and have automatic block signalling for short sections, such as round St. Louis and Chicago, and some of their large stations have their points and signals interlocked and worked by electricity or air pressure or by a combination of both. Many hundreds, perhaps, thousands of millions of dollars will, however, have to be spent by all the poorly equipped and poorly built lines to bring them up to European or Indian standards, and I am told that even to elevate the 700 miles of railway converging on and lying within the limits of Chicago fifty million dollars are being spent on this work alone. One sees these improvements going on on such lines as the Pennsylvania, the N. Y. C., the B. & O., the N. Y. N. H. & H., the B. & A., and their Eastern roads where the traffic is heavy, and the population steadily increasing. Here over- and under- bridges are being built, grade crossings of other lines and cart roads on the level are being done away with, neat stations, low platforms and decent fencing are being provided, and the lines are being made tidy and finished. One peculiarity of American platelaying is the fact that all rails break joint, one-joint being

opposite the centre of the other rail. This practice is universal and it is considered that bogie vehicles run better and are less liable to derailment with this method, and the Americans with 200,000 miles of road say they know and they ought to know, what is best, although their custom differs from the rest of the world; the advantage claimed is that only half the difference of the sag has to be manipulated by the body of the vehicle, as the pin of the bogie truck only goes down half of what it would have to do if the sag were under both wheels. Another feature is the large number of sleepers provided; they use from 2,500 to 3,150 per mile, versus 1,760 to 2,000 in India and England, and the result is a smoother and stronger track. Generally speaking, there are no raised platforms, but in some cases the platform is raised six inches to a foot, and on the I. C. R. R.'s suburban lines near Chicago, raised platforms as in England are provided with a view to save time in training and detraining passengers, but these particular lines are for suburban traffic only, and Americans are not likely, with their narrow spacing of tracks and wide vehicles, to adopt generally side opening doors and raised platforms for their main lines. As a rule, platforms at small stations are only 5 to 10 or 20 yards long, and naturally, length is not of importance where loading and unloading are done from the ground by steps at the end of each long carriage, but it is instructive as compared with Indian practice, where, I think, we go to the other extreme in providing 600 feet long and unnecessarily wide platforms at very small stations. Indian practice is also too expensive and rigorous in exacting foot over-bridges at every small station where there is only platform or where passenger trains may not all pull up at the platform. Where low or rail level platforms only exist, the American practice might, I think, be followed, for in America at every station I inspected, big or small, passengers, as a matter of course, are expected to have to walk across lines of rail to get to or from their carriage. American lines, with rare exceptions, run across one another, and across and through streets on the level in the West without any interlocking, the only caution exercised being the ringing of a bell on the engine, and this bell ringing is made automatic on several lines much to the annoyance of passengers. Some sort of fencing in nearly all cases is provided on all the lines I travelled over. Each State apparently has the right to insist on the lines within it being fenced, and this is made obligatory where the farmer himself has fenced his fields. The fencing is usually wretched in quality, consisting of a light wooden post, and three or four lines of barbed wire; the latter material for some reason, however, being considered unsuitable for keeping out the Indian public or cattle.

7. The majority of the railways of America, if I may judge them from such a short visit, are much as I expected to find them:—indifferent road beds, but the track itself is strong on account of the large number of sleepers used. The comfortable riding is due to the excellence of design of coaches. Their 75 to 80 feet long and very heavy cars ride splendidly, and defects in the road are not felt except at very high speeds. I had always thought that the long American coach was originally designed to obviate the defects of their cheap and indifferent roads, and I feel pretty sure that the discovery that a long and heavy bogie carriage rode safely and softly over an indifferent road resulted in the universal adoption of this type of vehicle, and every improvement in their carriages has aimed at further counteracting the want of perfection in their tracks.

Up-to-date Stations.

8. The best station I have ever seen is that of South Boston. It is complete in every way, and for its local traffic is provided with low-level tracks, which form a complete loop and run under the main line tracks into the basement of the station; these are not used at present, but when the traffic justifies it they well be put into service and the trains will be worked by electricity. The station possesses every convenience that can be thought of and its decoration is not too ornate and extravagant. Amongst

other up-to-date arrangements is that of handling luggage accompanying passengers, which, as is done at most big American termini, is collected at the side of the station, hauled on trucks below the level of the rails and delivered between the lines alongside the baggage cars by hydraulic lifts. The express baggage dealt with by the Express Companies is loaded and unloaded on short fan-shaped sidings along one side of the station and 300 to 400 large cars can be dealt with daily at Boston.

Every labour-saving appliance is used; even the plates and dishes are cleaned mechanically and the bread is cut up by a lightning saw. The freezing and air ventilation plants, too, are very complete, the temperature in each wine bin and store cupboard in the restaurant's pantry being regulated to a degree. I noticed a light frame-work on a truck provided with small wheels on which bicycles were hung by the front wheel on hooks, and the truck could then be run to and from the luggage cars.

9. The description of this station applies nearly word for word to the Union Station at St. Louis (photographs of which are given in Appendix B.), and the Central Station at New York City. The Albany Station, for its size, is also a very beautiful station, and very perfectly equipped. The Pennsylvania Stations at New Jersey City and Philadelphia, and the terminus of the Central Railway of New Jersey at the latter place, are also very fine indeed.

One feature that is worthy of notice in their new stations is the splendid accommodation given for ladies and children. In their toilet and waiting rooms which are luxuriously fitted up, baths, beds and childrens' cots are provided, and both for men and women the "free" closets and other conveniences are very clean and up-to-date, and the "to pay" ones extremely so. This is in marked contrast to the provision made in cities where, with the exception of Boston, I could not find a single public closet or urinal in the streets, and when at the Buffalo Exhibition one was nearly as badly off there

Electro-Pneumatic, all Electric or Pure Pneumatic Interlocking.

10. These methods of interlocking are gaining ground very rapidly in America, and one small plant of electro-pneumatic interlocking has lately been installed at the Bishopsgate's Goods Yard of the Great Eastern Railway in London. I understand also that the first system is being introduced at Bolton on the Lancashire and Yorkshire Railway Before going to America I took the opportunity of seeing the Bishopsgate plant in company with Mr. W H Cole, late of India, and a representative of Messrs McKenzie and Holland, who are the agents for the British Empire of the Westing-house Brake Company, Limited, and I attach pamphlets, etc., (Appendix A.) describing the system. There are 38 levers to work 25 signals, 43 points, and 3 lock-bars. I think that the Company has good grounds for claiming that the system is as efficient, safe, rapid in action, and is as economical a method of interlocking points and signals as has yet been devised for large stations, and I was greatly interested in a visit to the Boston Southern Station, a full account of which installation is given in the pamphlets referred to These remarks apply also to the Union Station at St. Louis and the P R R. terminus at Philadelphia. There is but little doubt in my mind that some kind of pneumatic or electric system will supersede existing mechanical interlocking at all large stations on account of the reduction in the number of cabins and avoidance of or diminution in the number of rods, pipes and wires required, and also because of the minimum space required for the newer systems. Any of these systems, too, can do their work at any distance with a small staff of operators, and they can do it more quickly and safely than any mechanical plant can carry it out.

The electro-pneumatic system seems also to have some advantages over purely electric interlocking, chiefly on account of the low voltage required, and as compared

with the purely pneumatic system, its outside connections are lighter, simpler, and less liable to damage, but the exact system that will be most successful is still a matter of opinion. The reserve air pressure required in the electro-pneumatic or high pressure air system can also be used at terminal stations to work pumps and pneumatic hoists, tools, and to clean and paint carriages, or supply power wherever it is required. It also has the advantage possessed by the "all electric" system that it fits in with automatic block signalling if the latter be introduced later on, *i.e.*, where trains do their own block signalling, as is in common use already on many railways in America. At any rate it appears as if pure mechanical interlocking has had its day, and it might be worth while to try one of the latest designs of electric or pneumatic installations at some large stations in India such as Delhi or Howrah. If any be thought of for any new station, I would suggest that for large installations the electro-pneumatic system may be one of those selected for trial. Certainly where no existing mechanical plant has to be superseded the new systems will prove themselves to be the cheapest in the end.

11. At Bishopsgate the air was compressed half a mile away from the cabin by means of the largest size Westinghouse pump, such as is used on American consolidation engines, the pump being simply connected to a steam pipe in the head boiler house, and the current was obtained from the electric light main. But a gas engine and compressor or dynamo could be used, were steam not available.

Electro-pneumatic interlocking is extensively used on the P. R. R., and I inspected the plant at the terminal station in Philadelphia. It is also used at the terminus of the C. and N. W. R. R. in Chicago.

12. The I. C. R. R use electric interlocking on their suburban lines near Chicago, whilst the N. Y. C. R. R. use a low-pressure air system in their central station yard. The P. R. R. also use electric interlocking largely. The U. P. R. R. have both "electro-pneumatic" and "all electric" interlocking installations at Omaha, and intend to extend this work.

13. At West St. Louis Union Station, I was taken over the fine terminal station used by the nineteen roads running into St. Louis, and the Vice-President and General Manager of the Terminal Railway Association, to which Company the Station and Belt Line belong, took me into the signal house at 7-30 A. M. on the 3rd May, this being the busiest hour. The system is exactly the same as used at Boston and Philadelphia, from which station the Boston Company copied it. It has been working since 1894, and I feel convinced that it is perfectly true as stated that the enormous traffic using the station could not be worked by any mechanical system. All trains are backed into the station, so that the engines and baggage and mail cars are out of the way of the passengers reaching their seats from the midway or end platform. The installation consists of 140 levers (of which 30 are spare) and about 280 trains go in and out per diem. In one hour 22 go out and 20 in, besides a large number of switching engines. In fact some 1,500 to 1,600 train movements are performed in one day and the work is done without a hitch. I attach two copies of a plan of the yard, together with a chart of the work done each day, as also a beautiful book illustrating the station, given me by the President, marked Appendix B.

At East St. Louis also, the old Saxby and Farmer interlocking plant, one of the oldest in the country, was just about to be replaced by a similar electro-pneumatic installation of the Union Switch Signal Company which is the system used at W. St. Louis, Philadelphia and Boston. The air power was used for cleaning carriages, dusting carpets and furniture, as also for jack work in lifting carriages, the air pressure in the latter case being pumped up to 170 lbs., and both operations I saw performed most satisfactorily. I am also satisfied that the pneumatic broom will be found extremely useful in India, and every American Railway had a good word to say for it.

14. On the 3rd June I inspected the interlocking plant at Boston South Station, and the General Superintendent of the N. Y. N. H. & H. R. R. told me it worked splendidly. I attach (as Appendix C.) a schedule of the train working, and I was told that in the summer season the number of trains handled would be increased to 775 a day. Sometime 49 trains have been despatched in 30 minutes without a hitch and up to time, twelve of these trains consisting of heavy excursion trains of 10 to 14 cars each. Only one bogie truck had been derailed in the last 16 months, and the damage done to stock in years passed had been infinitesimal. Sometimes 75 trains an hour in the morning and night hours are dealt with, and 3,000 movements per diem are effected. I noticed that electric lighting of signals was being used, two lamps being provided in each signal lamp, and I was told that a saving of 1,500 dollars a year under this item was being effected.

Automatic Block Signalling.

15. This is being extensively used in America where traffic is congested and every one I questioned spoke in its favour and said their busy traffic could not be worked without it.

On the P. R. R. from Jersey City for 110 miles south, and again some 33 miles around Pittsburg, the Union Switch and Signal Company's electro-pneumatic automatic system is used, but between Pittsburg and Homewood, a distance of 35 miles, the "all electric" system designed by the P. R. R. is adopted. The General Manager in Philadelphia told me that they were just extending the Union Switch and Signal Company's system to the Camden Atlantic City branch, 58 miles long, and to a 20-mile section between Philadelphia and Paoli.

16. On the N. Y. C. R. R., some 25 miles of electro-pneumatic automatic signalling exists, and this is being extended; about 40 miles of the U. S. and S. Co.'s "all electric" system is also being installed.

17. On the Chicago, Milwaukee and St. Paul R. R. electric automatic block signalling is also in use.

18. On the I. C. R. R. the "all electric" system is in use on the suburban and main lines near Chicago, and this system is also used in the same way near Chicago for 30 miles on the C. & N. W. R. R. The Burlington line also has the "all electric" system for 22 miles between St. Louis and Chicago and so has the Chicago & Alton R. R. between Chicago and Alton, a distance of 25 miles.

19. The C. R. R. of New Jersey works all its four tracks between Jersey City and Bound Brook, a distance of 31 miles, by the electro-pneumatic automatic block system, and from Bound Brook to Philadelphia, a distance of 63 miles, the Philadelphia and Reading line use the Hall electric automatic block system. The B. & O. R. R. are also adopting the latter system on their Philadelphia Washington section.

20. To show what faith the Americans have in the automatic block signalling system, I actually found, as described under the head "electric traction," an electric tramroad or railway running round trips in Fairmount Park at Philadelphia with the Hall treadle system in full operation.

21. The N. Y. N. H. & H. R. R. have both "all electric" and "electro-pneumatic" automatic block signalling, and they like both systems very much, the first being that of the Union Switch and Signal Company.

22. The B. & A. R. R. have some 44 miles of the "all electric" system and about 160 miles of the U. S. and S. Company's system, but the latter is not completely auto-

matic as it is the treadle system only which puts the signal to danger after the train has passed it, but the train does not clear its way before it.

23. Where absolute automatic block signalling is not in use, the N. Y. C. R. R. are using Sykes' Manual Controlled Block system. In this the operator's instruments are controlled electrically by the forward station as are also the outdoor signals, and the starting signal cannot be lowered until "line clear for the station ahead" has been received. The train then sets the signals at danger when passing them, and keeps them so until it arrives at the next block station; but it does not automatically work the signal ahead.

24. There is no doubt in my mind that English Railways will adopt some automatic system, and by and by perhaps for the suburban traffic near Calcutta, Bombay and Madras, it will have to be introduced into India. Descriptions of the systems in use in America are given as Appendix D.

Brief description of the Condition of the Roads I saw.

25. The P. R. R. Main Line East of Pittsburg has a 100-lb. rail, and so has the N. Y. C. & H. R. R. some distance north of New York. Both roads are in excellent order and well-ballasted, but neither is better than the E. I., the G. I. P., or the Madras Railways, did these Indian roads possess a 100-lb. rail, although the rails of the American roads are more truly laid and better maintained. All American railways I saw use a flat-footed rail, and spike the fish-plates to the sleepers, although the reporters for the Paris Congress considered this to be bad practice. Practically all roads use a six-bolted fish-plate of angle iron shape, the lower limb often extending some way beyond the upper surface of the rail foot. To save repetition this practice may be accepted as universal, and any variations from it will be noted in each case. Where not otherwise stated rails are 30 feet long.

26. The C. & N. W. R. R. which has a 90-lb. rail is somewhat inferior to the best Trunk lines in India. The U. P.R.R. has a 75, 80, 90, and 100 lb. rail and is ballasted with grit, but splendid gravel is now being put down. Its road also may be classed as a very good second class one compared with Indian Trunk lines. The standard length of their sidings is 4,000 ft., but they have some 5,000 ft. long.

27. The Denver and Rio Grande Railway may be described as a middling second class line with a very dusty road. It has 19 to 20 sleepers to the rail and is ballasted with grit, ashes, sand or earth. Most of its culverts consist of wooden baulks on timber piles, but its large bridges are steel trusses. It has some grades of 1 in 25 between Minturn and Tennessee Pass and generally speaking its grades are severe. Like all American roads, even counting in the P. R. R., its curves are much sharper than those generally permitted in India.

28. The general description of the D. & R. G. R. R. applies to the Burlington Missouri R. R. between Denver and St. Louis, a distance of 929 miles, except that although the standard now adopted is a 90 lb. rail, there are many old 65 and 75 lb. rails in the road. The ballast consists of ashes, burnt clay, stone, slag, and earth and the joints are down, but the line is neater than the D. & R. G. R. R. and the running is better.

29. At junctions and larger stations there is a small interlocking plant for points and signals, and many slip or derailing switches are used. Along the B. M. R. R. as on many other lines in the grain producing districts, there are small wooden grain elevators placed on a siding at most stations, and these can be built it is said for 1,200 to 1,500 dollars.

30. From St. Louis the Wabash Line is chiefly ballasted with stone as is the Chicago & Alton R. R., and some others running into St. Louis, but I should class most of the railways west of the Missisippi as second class roads, which in time will require a very large amount of expenditure to make them first class.

31. The Rock Island & Pacific is in about the same condition as the Burlington & Quincy Railway, a good second class road, ballasted with stone or grit or earth, and it has a great deal of 1 per cent. grade.

32. The Lake Shore R. R. is fairly ballasted with stone, gravel or grit, and has a good road and a heavy rail, but it is not up to the standard of the N. Y. C. R. R. proper. It has a mixture of four and six-bolt fish-plates and has about 17 sleepers to the 30 ft. rail.

33. The B. & O. route between Jersey City and Washington consists of parts of three systems: the Central Railway of New Jersey, a four-track road to Bound Brook 31 miles long, the Philadelphia and Reading to Philadelphia 63 miles, and the B. & O. to Washington 124 miles, each of the latter being a two-track road with the exception of one long single track bridge adout 1½ miles long north of Baltimore.

All this road is excellent in quality, and equal to the best Trunk line in India, being ballasted with hard stone and having a rail from 80 to 85 lbs. in weight, which, however, is now being replaced by one of 100 lbs. section. Sleepers are about 16 to the 30 ft. rail. There are many over-bridges and neat country stations.

34. From Washington to Grafton, a distance of 235 miles, the B. and O. is mostly a double track, but the rest of the system is chiefly a single track road. West of Pittsburg its road may be graded as a good second class one.

35. The B. & O. R. R. between Washington and Pittsburg is being made a first class line and very heavy renewals of rails, sleepers, and bridges are being made. Its permanent way is strong and well laid and the road is ballasted to about three quarters of full section with hard stone. Its curves are very sharp and its grades heavy, particularly in crossing the Alleghanies.

36. Some 20 miles of 60 ft. rails had been tried on a down grade in the direction of the traffic, but they crept a good deal, and gave trouble in expansion and contraction and they are now being put on the up grade line in the direction of the traffic. Some 100 lbs. rails were also being put in, but the present standard West of Washington was 85 lbs. There were 3,000 sleepers to the mile and the road was a strong one.

Cleveland and Pittsburg, R. R.

37. I travelled up and back between Pittsburg and Cleveland over the Cleveland and Pittsburg R. R. worked by the P. R. R. It is a single track second class road with weak rails, but it is well ballasted, and we did an average speed of 43 miles an hour over it. The end car rode comfortably.

P. R. R. East of Pittsburg.

38. On the 23rd May I travelled through the Alleghani Mountains over the P. R.R. between Pittsburg and Altoona. It has very heavy grades and sharp curves, but is a first class road. It has a mixture of 85 and 100 lb rails, but a 100 lb. rail is being put down for renewals. It is mostly a four-track road with very heavy traffic on it and heavy renewals were going on. The number of sleepers to the 30 ft. rail was 14 to 15.

39. The N. Y. C. R. R. track, of which I inspected 40 miles out of New York from a special train provided by the Railway Officials, is a very first class one, the joints being

the best I saw on any line. Mr. Dudley, the Inspecting Engineer of the road, the Engineer of Maintenance, and the Train Master, Hudson Division, accompanied me and the road was in splendid order and the joints not to be felt at all. The standard rail is 33 feet long and 100 lbs. in weight, and has 20 sleepers under it, and this section is to be adopted as far as Albany. The line is well ballasted with stone and requires little maintenance, the average number of track men employed during the year per mile of single line being seven-tenths of a man only. I also inspected by special train with the Divisional Engineer at Albany the track between Albany and Schenectady, a distance of 17 miles. The rails here and up to Buffalo and also for some distance south of Albany are only 80 lbs. in section with 18 sleepers to a 30 feet and 20 to a 33 feet rail. The ballast is a coarse gravel, but broken stone is being arranged for. Where curves are six degrees or more, reinforcing braces on the outside of the two rails are used, except where tie-plates are put down. Spring rail frogs are very freely used, as is the case on most American roads. The Divisional Superintendent told me they were absolutely safe, and were introduced in order to lessen the shock to main line traffic vehicles, and I believe they effect this object, I had an engine run over one several times, and I believe such frogs would be found an improvement in India, particularly for facing points. Slip switches too abound in America and should be tried in India. We are too much afraid of diamond crossings and slip switches in that country, whereas in America they are to be found everywhere and are quite safe. (For description, *see* International Congress Paper No. 3 of 1890).

40. The N. Y. N. H. & H. R. R. is very much like an English road, with over-bridges, neat stations, block cabins and usual signals, and with most of its signals and points interlocked. Between New York and New Haven it is a four-track line, which is also the case near Boston; the rest of the coast route is two track. Steel bridges are being put in everywhere, and the public roads are being crossed by over-bridges. The ballast is full in section, and up to New Haven is of good stone; north of that it is either coarse sand, grit, or gravel, and on one section of about 20 miles the dust flew about like it does on a sandy road in India, but our speed was over 50 miles an hour. The rail is a strong one 100 lb. in section and 30 ft. long, and is supported by about 15 to 17 sleepers per 30 ft. rail, and like other American roads it is reinforced on some curves by the addition of a kind of chair on the outside of each rail, the chair being spiked to every fifth sleeper. The road is good and up to the best Indian Trunk line form, but its fish-plates are weak and the joints are down.

41. The main signals show red and green for "danger," and "proceed," but the distant signals have yellow and green for "danger" and "proceed," and these colours have also been adopted by the Canadian Pacific Railway and the B. & O. R. R., and the "Big Four" system are also trying them for their distant-signals, the object being to do away with the objectionable practice of running through any red signal at danger. I attach (as Appendix E.) a specimen of a sort of corrugated yellow glass, which, after numerous trials, has been found to be the best for lenses of the distant signals.

42. The Boston and Albany R. R. has four tracks for 16 miles out of Boston, and two tracks the rest of the way to Albany, which is 203 miles from Boston, and is ballasted with coarse gravel. Its grades are steep, the ruling gradient being 82 feet to the mile. From Boston it ascends 900 feet and then falls almost to sea level, thence it rises to 1,436 feet, and again falls to 20 feet above sea level at Albany, consequently it can only haul eight or nine coaches with one engine and 1,000 gross tons on its freight trains. It has 53 per cent. of curvature. Its rails are 30 feet long and of 95 lb. section, with 15 or 16 sleepers to the 30 feet rail. No 60 feet rails have been used, but the Chief Engineer thinks they should be successful. Its road is excellent, and its stations are very neat and up-to-date and resemble English ones, being built of good masonry with neat stone or paved low platforms. Each tie has a tie-plate, and since their introduction the reinforc-

ing braces or chairs on curves have been found to be unnecessary. I noticed here, as is the case on many American railways, the anti-creep chairs which are put in opposite the joints of the other rail. They consist of a chair fastened by one bolt through the web of the rail and spiked to the sleeper by one inside and one outside spike, and the Chief Engineer said they were most effective. The B. & A. R. R. were one of the first, if not the first road, to adopt a heavy rail, and the Chief Engineer told me it had been a perfect success, they having had a 95 lb. rail for over ten years.

Rails and Rail Joints.

43. As mentioned in the report on the Paris Congress, much advantage is claimed by the Americans from the use of a heavy tough stiff rail of great tensile strength with a good broad top surface, and Mr. Dudley, the Inspecting Engineer of the N. Y. C. and B. & A. Railways, states that he has reduced the resistance to traction on the N. Y. C. & H. R R. by 100 per cent., by the substitution of such a rail of 100 lb. section for one of some 70 lbs. in weight. He also claims, and apparently succeeds in proving by figures that on the two railways with which he has been connected, the cost of transportation, maintenance of way expenses, and cost of renewals of rolling stock, have shown a steady decrease with every increase of rail section. Heavier trains have been hauled, less fuel per train mile has been consumed, a better road has been kept up at less cost and the rolling stock has required less up-keep. It is not that the heavy rail shows less wear than the lighter one—the contrary is the case; but the destructive work takes place chiefly on the rail head, and this saves the sleepers from deformation and makes the surface better, and consequently makes haulage lighter and damage to rolling stock less. These results agree with the opinions I have always held as to the ultimate economy to be obtained by using heavier rails, and I never associated, as some people do, light permanent way with cheap lines. I have always questioned the wisdom of the Government of India in holding on so long to a rail of 75 lbs. in section for the State broad gauge lines, for it is doubtful if there is ultimate economy, even when the price of steel is high, and when it is low, as it probably will be again, there seems to be no good reason why a 75 lb. rail should be considered the right weight for a 5 ft. 6 ins. gauge, even for existing loads, when English railways with a 4 ft. 8½ ins. gauge have long since adopted a rail between 90 and 103 lbs. in section. Light rails, in my humble opinion, are always the dearest in the end, even for so termed light railways, for the stonger the permanent way the lighter the work below it can be, and it is only lack of capital that can be accepted as the excuse for the laying of a light rail. On several American railways 60 ft. long rails are being used as on the English L. and N. W. Railway, where they make a most excellent road, and with a view to minimise the "joint" trouble a ship-load might be sent to India to see if they can be transported without damage and put in the track in a "true" condition. This may have already been done for all that I know. American railways, which originally started with very light rails fastened to a large number of sleepers per rail, are rapidly descarding this type for a heavy section rail and reducing the number of sleepers, and no one can say that ten years hence India may not be hauling loads, and permitting axle loads such as are in common use to-day in America, and for this purpose they will require a stouter rail. That the hard heavy rails last well is proved by the condition of the 100 lb. rails I inspected near the site of the Grand Central Station of the N. Y. C. & H. R. R. in New York, where only one-eighth of an inch in height has worn off for 80,000,000 tons of traffic, and this with average engine axle loads of 20-tons. The following are the weights per yard of rails now being put down on some of the principal lines:—P.R. R. East of Pittsburg, 100 lbs.; Pittsburg, Bessemer, and Lake Erie R. R. 100 lbs.; West of Pittsburg, 85 lbs.; N. Y. C., 100 lbs.; N. Y. N. H. & H. R. R., 100 lbs.; B. & A. R. R., 95 lbs.; Chesapeake and Ohio R. R, 100 lbs.; Duluth and Iron Range R. R., 100lbs; West Jersey and Sea Shore R. R., 100 lbs.; Illinois Central, 85 lbs.; Chicago and

N. W. R. R., 90 and 100 lbs.; Union Pacific, 80 lbs.; Omaha to North Platte, and then some 75 old rails west of this. Their standard further west is 90 lbs., and they are putting down 100. lbs. near Sacramento. Denver and Rio Grande R. R. have adopted 99 lbs. as their standard, and so have the Burlington Missouri R. R. The Wabash use 80 lbs., and most of the railways in Illinois and the country centreing round St. Louis have 85 lbs., but their traffic and loads are not as great as those on the Eastern roads. The New Jersey division of the Central Railway of New Jersey, the Philadelphia section of the P. R. R., and the Philadelphia-Baltimore section of the B. & O., have 80 to 85 lb. rails in their road, but they are now putting down a 100 lb. rail all over this section, and the General Superintendent of the latter line told me that the heavy traffic on this section had forced them to adopt this section. West of Baltimore the B. & O. will adhere for the present to 85 lbs. as their standard.

44. It will be noted that the Paris Congress inclined to the view that supported or bridge joints were the best, and I have always wanted to carry out trials to test this opinion. On the face of it, it has seemed to me to be reasonable to suppose that if the rails can be made of hard enough material so as not to let the heads wear unevenly at the joints, the best joint is one where the rail ends rest either on a substantial sleeper or in a chair or trough, or any support which bears on the two adjacent sleepers. On the L. and N. W. Railway, where the new rails are 60 feet long and 103 lbs. in section, the Carriage Superintendent told me that the stock ran perfectly and suffered no unusual damage, and it has not been proved, so I think, as many people suppose, that a heavy stiff road is more injurious to stock than a more elastic road. The experiments made in America, on the contrary, show the superiority of the heavy stiff road, as affecting repairs to rolling stock, and when we have in America engine axle loads of 23 tons and over, and in England, so I am told, of 20 tons, the stronger the rail joint can be made the better it must be.

45. On the N. Y. C. R. R. the best joint is considered to be one where the rail ends rest on a sleeper and the fish-plate bridges three sleepers, the ones on each side of it being close to it; the rails are 30 or 33 feet long, though some 60 feet in length are being used. The 30 feet rails have 18, and the 33 feet 20, nine inches wide sleepers under them, and the ends of the rails rest on a tie-plate on the joint sleeper (Wolverhampter pattern). The fish-plates are 36 ins., 40 ins. or 42 ins. long, of angle iron pattern, and have six bolts. This permanent way makes a splendid road, and is to be the standard between New York and Albany, and I can testify to its excellence from experience in travelling on two occasions by special trains on that line. The joints could not be felt at all, even where the rails had been down since 1892 and had 125 millions tons of traffic over them, and they were considered capable of standing 75 millions tons more.

46. Personally I consider this supported joint (of which I attach a ferrotype as Appendix F.) to be the best I saw in America, and the opinion of the N. Y. C. R. R. authorities, who, like the P. R. R., have tried every kind of joint, is that the Stremmatograph and other instruments for recording the stresses and deformations in the track show that this is the best joint tried. It is also a cheap joint, and I would strongly suggest that it be given an exhaustive trial in India. I would, however, like to see the fish-plate made a little thicker, and bearing plates put on each sleeper, and certainly at the three joint sleepers that the fish-plates rest on. I was told, however, that it took 90,000 lbs. strain to move the rails inside the 40 in. fish-plates, the frictional resistance being 4,500 lbs. per lineal inch of plate. These plates, too, are made of a very high grade steel, possessing an elastic limit of 55,000 lbs. per square inch. I would also suggest that the P. R. R. standard joint No. 1, elsewhere described, be tried in India.

47. The B. & A. R. R.'s joint is a fairly good supported one, the fish-plate being stout in section; but it is only 20 inchec long with four bolts. Its foot however extends one

inch to $1\frac{1}{2}$ inches beyond the foot of the rail. It would, I think, be better if it were longer, with six bolts, and were supported on three ties. This line, which is one of the oldest, and has one of the best roads in America, has never had anything but the supported joint.

48. The N. Y. N. H. & H. R. R.'s joint is a suspended one with a four-bolt ordinary angle-iron shape fish-plate. It is weak and the joints are down even with a 100 lb. section rail. It is the one defect in an otherwise first-class track.

49. I may say that I found a few Managers out West, who had tried them, objected in a measure to the 100 lb. rails, simply because they thought those tried did not wear well. This is because in many workshop plants the same sized blooms had been used for the 75-lb. as for the 100-lb. rail, and consequently the rolls did not do the same work on the heavier rail. This defect, however, has now been remedied, so the P. R. R. and N Y. C. R. R. tell me, and it was generally admitted that when this has been done the heavier rail would be preferred.

50 On the Central Illinois R. R. there are 18 sleepers to the 30 feet rail, whilst on the Chicago and N. W. R. R. there are 16 to 18, and the standard under adoption on the latter railway is 17.

51 Just East of Pittsburg on the P. R. R. I inspected one end of a length of 1,000 feet of rail, the ends of which have been made to butt tight against one another, leaving no expansion. The ends of this section are anchored firmly into the formation, and anti-creep chairs bolted through the rail are used in addition to the ordinary deep angle-iron fish-plates at the joints But although the experiment, which had not been under trial very long, was considered satisfactory, it is doubtful if it would succeed in India.

52 The Superintendent of the Division of the P. R. R. West of Pittsburg took me out some 30 miles from Pittsburg and back to see the road, and it was evident that the 85 lb. rail (no 100 lb. section being used West of Pittsburg) did not make as good a road as the 100 lb. track. The fish-plates are six-bolted ordinary angle-iron pattern, and the road was not quite up to the standard of the best Indian trunk lines.

53. The U. P R. R. use by preference a 42-inch fish-plate, the joint resting on a sleeper They use 17 sleepers 8 ft. by 8 ins. by 8 ins. to a 30 feet rail, and tie or bearing plates are being put on each sleeper.

54. The Denver & Rio Grande and the Burlington Missouri R. R. follow the same standard, but they also have many four-bolted fish-plates in the line and their joints are weak and down.

55. The fish-plates used by nearly all the railways centreing at St. Louis are of the usual type, but with the exception of the Burlington, and the Illinois C. R. R., most of the railways converging on this station used the suspended joint with sleepers very close to the joints

56. On the Rock Island & Pacific R. R. the sleeper is put under the joint, usual angle-iron fish-plate resting on the central and adjacent sleepers.

57. On the New Jersey Division of the Central Railway of New Jersey the standard fish-plates were about 36 inches long with six bolts, and they embraced both the upper and lower surfaces of the flange of the rail, almost meeting underneath, whilst their ends rested on the two sleepers nearest the joint, the joint being between the sleepers spaced close together; this is called a continuous joint and is really a bridge joint, but it is vertically weak for the weight of metal put in it.

58. The Philadelphia & Reading, and the Baltimore & Ohio Railways are adopting this continuous joint as their standard, and the General Superintendent of the latter Railway at Baltimore said he considered it to be an excellent joint. Between Washington and Pittsburg the continuous fish-plate adopted however is four-bolted only, and is 24 inches long.

59. As regards the P. R. R, I am able to furnish a most interesting ferrotype diagram (Appendix G.) given me by the Chief Engineer, which represents pictorially the history of their rail joints. All kinds have been tried, including the Fisher joint and the continuous joint of the B. & O. R. R. The former was not considered satisfactory, as the metal parts of which it was composed wore badly one against the other and the parts were too numerous and wore loose. The B. & O. R. R.'s continuous joint was also considered faulty, first, because of its vertical weakness, as is undoubtedly the case, and secondly, because it broke at the angle of the web and lower flange.

Eventually the P. R. R. Co. has come to prefer the joint marked No. 1, that marked 2 coming next in favour. The joint is a modified Bonzano joint, and I append (Appendix H.) a picture and description of this patent joint, in which is shown the standard P. R. R. joint. I am also able to supply two models of the P. R. R's standard joint, given me by the Chief Engineer, the only difference being that in actual use, six bolts and not four, with a longer plate, are used. I think the joint is a good one and is vertically strong, but all the same, I have a predilection for a sleeper under the joint. Tie or bearing plates under the rails are only considered good when fixed on every sleeper, the only reason for omitting them being economy. I may say that 20 miles of track between Altoona and Harrisburg are used as an experiment ground for trials of permanent way. I am able, through the Chief Engineer's kindness, to supply also a ferrotype (Appendix I.) showing the number of sleepers, their dimensions and proportion of bearing surfaces, on the P. R. R. and some other important lines, including the L. & N. W. Railway.

60. As regards the question of heavy rails and long rails, the Chief Engineer was strongly in favour of a 100-lb. section, which is the standard on the P. R. R. East of Pittsburg, and he said it had been suggested that by-and-by a 120-lb. section rail might be necessary, and this is not impossible. He said that new rolls were now being used at the mills, and the quality of the metal was satisfactory, and he preferred, as do the N. Y. C. R. R., a hard metal. As regards 60 feet rails, he said he did not like them because they had been found to expand and contract abnormally and crept a good deal under heavy freight traffic, but I think this occurred, as on the B. & O. R. R. on down grades in the direction of the traffic. Rails 100 feet long had also been tried and were not liked for the same reasons. On the Camden-Atlantic City Branch, however, where the traffic, though very fast, was light and chiefly confined to passenger service, the 60 feet rails had given satisfaction.

Ballasting.

61. Ballast hopper cars carrying 80,000 to 100,000 lbs. are being generally used now. The metal drops between the rails, and a board or plough is fixed to the end car and the car is pushed along at about two miles an hour and levels the bellast to about rail level, clearing also a flange way. It is said not to obstruct traffic, and it might with advantage be tried in India, as its rate of progress is rapid and consequent cost of hire of rolling stock is low, and this after all is a large factor in the cost of ballasting. The quantity deposited can be regulated by the extent to which the bottom doors are opened. The U. P. R. R's pressed steel ballast gondola cars carried 80,000 lbs., weighed 32,800 lbs., and were 36 feet long over sills. The N. Y. C. R. R. use the 100,000lb. capacity car extensively. It carried 110,000 lbs. and the Engineer of Maintenance of the

Hudson Division told me they liked them very much, and that a car only took one minute to unload, and that a train of 30 cars could be unloaded and the track made clear for traffic in half an hour. Each 110,000-lb. car weighs 34,000 lbs., is 46 ft. long over body, and has 8 ft. 10 in. sides, and carries 38 cubic yards of ballast. They also told me they were using ordinary high sided pressed steel hopper cars, which worked satisfactorily except that it was difficult to regulate the spread; at any rate this shows a second use, for this class of special type wagon.

Oil Sprinkling of Ballast.

62. Both the General Manager and the Chief Engineer of the P. R. R. at Philadelphia gave me their opinion of the merits of oil sprinkling the ballast, and the latter furnished me with a pamphlet on the subject which I attached (as Appendix J.) The opinion was that for speeds not exceeding 40 to 45 miles on a dusty road, it was most efficacious, and the Chief Engineer considered it was certainly worth a trial in India. For higher speeds, especially where fine grit, sand, or small gravel was used, although the oil sensibly kept down the dust, still a certain amount of dust flew about, and it was then more objectionable than ordinary dust, as it consisted of a mixture of oil and dust. For stone ballast it was not considered necessary. No complaints from the platelayers had been received; on the contrary, it was helpful to their work. It is still being used by the P. R. R., especially at small crossings in the country, and for tracks where the ballast is gravel, and for many poor tracks where the speed is low. During the first year, two applications are necessary, but after that one is usually found sufficient.

At first the cost was trifling, as the almost worthless thick refuse of petroleum was used, and it cost only $40 a mile.

63. The N. Y. C. & H. R. R. Engineer of Maintenance, Hudson Division, told me, however, that the cost was so high, being for his Railway as much as $ 190 a mile of double track, and he thought it would be cheaper to ballast the line with stone, which would cost $1,500 a mile of single track.

64. The N. N. H. & H. R. R. have had one year's trial with oil sprinkling, and they were not quite satisfied it was a success, as the speed of their passenger trains is high, sometimes 50 to 60 miles an hour between stations.

65. The B. & A. R.R. have had three years' trial of oil sprinkling. The General Manager told me he considered it was a success, and that it was certainly effective if oil could be got cheap. During the second year they had one or two complaints in the hot weather from passengers who complained of a spray of oil and dust falling on their persons or clothes. Their ballast is gravel, but is dusty and dirty.

The Chief Engineer and General Superintendent also told me they thoroughly believed in it, and that it cost $50 per mile of single track for a dose of 1,000 gallons of oil per mile, the first application, however, consisting of 2,000 gallons per mile. I rode over the line in June, and I am certain the dust was much less than it would have been had no oil sprinkling taken place 11 months before. I do not prophesy that it will be a success in India where in the hot dry weather not only the formation but the country on each side is covered with dust, but for sandy road beds, where fair speeds are attained and where oil can be purchased cheap, it is certainly worth a trial.

Coaching Stock and description of some of the Trains, and runs made by them.

66. It seems almost unnecessary to say anything in favour of long bogie stock. Before leaving India, sanction was obtained by me to a programme for additional coaching stock and for all renewals for both broad and metre gauge sections of the Eastern Bengal State Railway to be of bogie design, and it may be assumed that the practice is becoming universal in India, as it is all over the world. The only points left for

consideration then are those concerning length, breadth and side versus centre corridors, as also the number of wheels, under the bogie truck. As a rule in England, carriage trucks have four wheels, excepting long dining cars which have six. The longest coaches have outside dimensions of about 65½ feet and width 8 ft. 6 ins., and weigh nearly 40 tons, whereas American cars run up to 48 to 50 and in some cases to 55 tons in weight, are 75 to 80 feet long over buffers and are 10 feet wide outside. From repeated inquiries I gathered that the weight of an ordinary coach on a long distance train might be taken at 75,000 lbs., whilst the weight of Pullman's sleepers, drawing-room and dining-cars would average 100,000 lbs, some of them weighing as much as 125,000 lbs. The Carriage Superintendent of the L. & N. W. R. R., the stock of which railway is up to date and excellent in design, told me that he considered British carriages might be widened six inches, if outside handles and all outside projection and side doors opening outside were abolished, and that the only reason why English railways could not go to 10 feet in width was on account of the numerous tunnels, otherwise the 12-feet centre to centre of tracks would admit of vehicles being 10 feet wide over all as they are in America. He considers, and I endorse his opinion, from constant travelling on the L. & N. W. Railway, where I have been living for over a year, that side corridor carriages run just as steadily as centre ones, but this question and that of the interior division of carriages is one best left to individual railways to decide. All I would say is that I have often thought that those Indian railways whose traffic is chiefly confined to their own systems, such for instance, as the N. W. and E. B. S. Railways, might be permitted to use broader carriages and wagons for purely local work. It is open to argument also whether the policy of binding all railways, strictly by the conditions existing on the old Trunk lines is a sound one, to be adhered to for ever; and if a 4 ft. 8½ in. gauge line in Great Britain can work stock 8 ft. 6 in. wide and American railways can go to 10 feet, and some Continental systems even to 10 ft. 6 ins., it seems a pity that such a wide gauge as 5 ft. 6 ins. should be restricted everywhere to 9 ft. 6 ins. for its useful width. Until one has travelled in a wide American carriage one does not appreciate what the extra 18 inches means.

67. It may here be noted (*see* Congress Paper No. 9, on Ballasting, Appendix K.) that nearly all of the American Busy trunk lines are spaced only 12 feet centre to centre of tracks, which is the same minimum prescribed in India for all old lines, and if Indian railway carriages were fitted with no side doors, as in America, or were the minimum spacing of tracks increased, as I think might be done on several lines, to 13 feet, we should be able to get additional seating and goods space accommodation, and might have 10½ feet carriages.

68. It might be well to note the chief exceptions to the 12 feet spacing between centres of tracks. They are the P. R. R. 12 ft. 2 ins., and the Chesapeake & Ohio, the Erie, the Burlington & Quincy, and the Philadelphia & Reading and the West Shore Railways with 13 feet, although some of these have their tracks in their goods yards only, 11 feet centres, and it will thus be seen that the lines carrying the heaviest traffic, such as the Pennsylvania, the N. Y. C. system, the N. Y N. H. and H., and the B. & O. and B. & A. Railways have only 12 feet centres as in India. (The P. R. R. 12 ft. 2 ins. is taken as 12 feet).

69. I inspected many of the finest American passenger trains, and travelled in a good many of them, including the Lake Shore Limited, the Empire Express on the N. Y. C., and the Lehigh Valley Black Diamond Express, the Florida and Metropolitan Limited Express, the Seaboard Air Line Express, the Congressional Limited, and the P. R. Limited Express, the five last using the Jersey City P. R. R.' s terminus.

I also travelled on the B. & O. Royal Blue Limited, and other of their best trains. All of the Pullman or special cars are magnificently fitted up, some lighted up with electric light and some with Pintsch's gas, and there is no doubt that the extra width

and height over English railway carriages gives them a more imposing appearance and makes them more comfortable.

70. The accommodation given in their ordinary coaches is, on the whole, about equal to that given in the latest type third class carriages in England. Thus, the Congressional Express give a seat in their ordinary coach for 2·85 cents a mile, with $1 extra charge between Jersey City and Washington for a seat in the Observation car. I travelled also in the Pittsburg Express on the P. R. R. to Pittsburg, and then on to Chicago by the C. & N. W. R. R., and from Chicago to Salt Lake City by the Colorado Express. The latter train averages for its first run of 202 miles with the same engine 34 miles an hour, with seven to nine coaches, each averaging 100,000 lbs. The U. P. R. R. on their main line do for the first 375 miles west of Council Bluffs, with six to nine coaches, 43 miles an hour (average speed start to finish).

71. The Burlington-Missouri R. R., Denver to St. Louis, by which I travelled, consisted of 10 coaches, weighing 300 to 400 tons, and did the distance, 929 miles, in 25·56 hours, or an average speed of 36½ miles.

72. On the 10th May I travelled by the B. & O. Royal Blue Limited from Jersey City to Baltimore. It did the run from Jersey City to Washington 228½ miles, in 4 hours 48 minutes, equal to an average speed of 47⅝ miles per hour, and riding in the observation car I can certify that with a speed that often rose to between 50 and 60 miles an hour, the car ran perfectly comfortable. The train consisted of seven cars averaging 110,000 lbs. each.

73. Some of the cars on the Royal Blue Limited run up to 78 feet over buffers, and weigh as much as 120,000 lbs. On the 17th May I travelled in the same train in the observation car from Washington to Baltimore; the distance, 40 miles, was done in 45 minutes, or an average speed of 53⅓ miles an hour from start to finish. A special train is said to have just run 70 miles in 64 minutes from Atlantic City to German Town junction on the P. R. R.

74. The N. Y N. H. & H. R. R.'s fast trains between New York and Boston do the run of 233 miles at a speed of 46⅗ miles with eight coaches, and with 15 vehicles they will do the same journey at a speed of 39 miles.

75. In Paper No. 12 of the Paris Congress of 1900, the average through speed stops not deducted, of the N. W. Limited No. 11 train between New York and Buffalo on the N Y. C. R. R. is given as 43 miles, but train No. 3 at present does the distance in 20 minutes less. The run is 445 miles, and the weight of No. 11 train behind the engine is 564 and sometimes 700 tons, the number of stops being six; weight of 10-wheeled engine and tender was 270,900 lbs. with boiler pressure of 200 lbs. The steepest grade on the run was 52½ feet per mile for a length of 3·1 miles, the longest grade being 11·6 feet per mile for a distance of 32 miles. The lighting of the train is furnished by a dynamo installed in the front baggage van, worked by an engine to which steam is supplied from the engine. The Empire State Express, a faster train, does the run daily in 8¼ hours, or an average speed of 53·6 miles per hour, with a load of 200 to 300 tons.

76. On the P. R. R. No. 209 train, with a load of 287 tons, and no stop, ran the entire distance, 583 miles between Camden and Atlantic City at an average speed of 63·6 miles. The weight of engine and tender, the former being of the Atlantic type with 10 wheels, was 263,450 lbs., and boiler pressure 185 lbs. The steepest grade was 27·36 feet for a length of 0·62 miles, the longest grade being 26·9 feet for a length of 4·3 miles.

77. On the 20th April I travelled by the Congressional Limited between Jersey City and Baltimore, doing the distance, 186 miles, at an average speed of 46½ miles an hour,

the first run of 91 miles without a stop being got over at an average speed of 53½ miles an hour, and at this speed the observation car rode beautifully steady and went round sharp curves at this pace quite comfortably. There were six cars 75 to 80 feet long, or a total weight of 300 tons behind the engine.

78. On the N. Y. C. R. R., on the 19th April, I saw the Lake Shore Limited start from the Central Station with ten 75 to 80 feet coaches behind it, averaging 50 tons each. On Saturday afternoon 13 coaches are often taken, and they keep time, doing an average speed of 50 miles between stations. The train is hauled by the passenger engine of which I append a photograph marked Appendix L. Its leading dimensions are: cylinders 21 in. x 26 in.; drivers 79 inches diameter; weight on four drivers 95,000 lbs., and on bogie truck 81,000; total 176,000 lbs. When required, or in starting, the adhesion can be increased by 9,800 lbs. by an engenious arrangement actuated by air pressure by which the weight on the trailing wheel is removed and transferred to the drivers. Boiler pressure is 290 lbs.

79. This immense engine, like all others in America, is driven by one driver and fireman, and the driver of the L. S. Limited I described above, is the man who drove the remarkable train of 16 coaches, weighing 920 tons, with an engine practically of the same type, on the 19th August 1899, of which I give a ferrotype as Appendix M.

80. This is a world's record, and is described in Mr. Dudley's paper No. 1, and referred to by me in my report on the Paris Congress, and as it was such a wonderful performance I give below full information as to its weight, speed and performance, as vouched for by Mr. Slack, the train master, who rode on the train.

Transcript of Run of Train No. 11, 19th August 1899.

Conductor, C. E Webb.	Engineman, A. Allen.
Train No. 11.	Café cars. 1.
Engine No. 948.	Coaches, 5.
Postal cars, 2.	Dining cars, 1.
Drawing-room cars, 3.	Sleeping cars, 4. Total cars, 16.

—	Miles from New York.	Miles between Stations.	Time between Stations.	Schedule Time.	Running Time.
				P.M.	P.M.
G. C. Station	—	—	—	1·00	1·05*
125th Street	4·38	—	—	1·09	— †
Mott Haven Junction	5·30	·92	15 mins.	1·13	1·20‡
Spuyten Duyvil	11·15	5·85	10 "	1·23	1·30§
Yonkers	15·22	4·7	6 "	1·29	1·36
Dobbs Ferry	20·71	5·59	8 "	1 34	1·44
Tarrytown	25·28	4·57	5 "	1·39	1 49
Sing Sing	30·90	5·62	7 "	1·45	1·56‖
Croton	34·42	3·52	5 "	1·49	2·01¶
Montrose	38·84	4·42	6 " †	1·54	2·07**
Peekskill	41·29	2 45	3 "	1·59	2·10
Highlands	46·10	4·81	6 "	2·05	2·16
Cold Spring	52·56	6·46	7 "	2·14	2·23
Fishkill Landing	58·98	6·42	9 "	2·21	2·32
Low Point	62·52	3·54	5 "	2·25	2·37
Poughkeepsie	73·48	10·96	12 "	2·41	2·49††

* Delay in getting train off two tracks and coupling up.
† Long stop on account of heavy passenger traffic.
‡ Slow order, 110th Street to 138th Street, and 10 miles per hour around Mott Haven Junction.
§ Slow up around Kings Bridge curve, and 10 miles per hour around Spuyten Duyvil Junction.
‖ Ten miles per hour over Croton River Bridge, account of construction.
¶ Slow up for water-track tank.
** Slow up through Peekskill.
†† Delayed three minutes loading passengers, mail, and baggage.

No. 89.

——	Miles from New York.	Miles between Stations.	Time between Stations.	Schedule Time.	Running Time.
				P.M.	P.M.
Poughkeepsie	—	—	—	2·43	2·54‡‡
Hyde Park	79·25	5·77	12 mins.	2·51	3·06§§
Staatsburg	83·70	4·45	6 „	2·56	3·12
Rhinecliff	89·08	5·38	8 „	3·03	3·20
Barrytown	94·69	5·61	6 „	3·10	3·26
Tivoli	99·01	4·32	5 „	3·15	3·31
Germantown	104·56	5·55	7 „	3·22	3·38‖‖
Hudson	114·45	9·89	14 „	3·37	3·52¶¶
Stuyvesant	124·27	9·82	13 „	3·50	4·05
Castleton	134·29	10·02	9 „	4·02	4·14
Rensselaer	142·39	8·10	10 „	4·13	4·24***
Albany	142·88	0·49	5 „	4·15	4·29

‡‡ Lost four minutes using single track, account re-construction.

§§ Slow up for water at Hyde Park track tank.

‖‖ Slow up for water at Linlithgo track tank.

¶¶ Slow up for B. and A. crossing at Hudson.

*** Four miles per hour over Albany Bridge, account re-construction, and slow up through Rensselaer, and B. and A. crossing.

81. Report by Train-Master of Passenger Train No. 11, run on the 15th August 1899:—

"This train was made up as follows:—Engine No. 948, two postal cars, one café car, five coaches, three parlour cars, one dining car, and four sleeping cars.

"There was a delay of five minutes in leaving, attributable to having train placed for loading on two tracks, owing to its greater length than ordinary and making it necessary to couple up both portions of it after the doors had closed at one o'clock.

"You will note herewith the various slow-ups between New York and Albany, in detail, with approximate loss of time for each, as you may see by referring to tabulated statement. You will note the fastest time was made between Stuyvesant and Castleton, a distance of ten and two one-hundredths miles in nine minutes, over a practically straight and level track; there being ten curves in the section, all very flat, varying from 30 mins. as a minimum to 2 degs. 30 mins. maximum, the grade for the ten miles being absolutely level for seven miles, and a rise of five feet in the next three miles. I am thus exact in these figures, as this seems to be interesting portion of the whole run, where a train of 16 cars, of an approximate weight of 920 tons, including engine, maintained a speed of 72 miles per hour for the time and distance.

"Attached is transcript of train sheet, with distances from New York, distances between stations, schedule time, running time, number of minutes between stations, and memorandum of slow-ups, and stops, in detail, as they occurred.

"I rode on the engine of this train from New York to Poughkeepsie, and while a high rate of speed was maintained the train ran very smoothly, with no appreciable surging, even in the highlands, where approximately 50 miles per hour was made with the train on reverse curves in places between Signal Towers 39 and 40."

82. To show what an English train can do, I give the performance of the special boat train which brought us up from the Liverpool Landing Stage to Euston on the 28th June 1901.

The train consisted of two engines, three six-wheeled vehicles, and 11 bogie carriages; its weight might be put at 326 tons. We left Edge Hill, Liverpool, at

8·25 a.m., and ran the distance, 192 miles, to Euston, in 3 hours 50 minutes, which is equal to an average speed of 50 miles per hour. No stop was made except where we were once pulled up by signals for half-a-minute. From Blisworth to Sudbury, a distance of 55 miles, the time was one hour, equal to an average speed of 55 miles per hour. This is a fine performance and the two engines ran like one. The carriages rode very comfortably, but it must not be overlooked that the L. and N. W. R. has the best maintained road in the world, and there are no better running carriages in England. Such a train however would have been handled by one engine in America.

83. I am convinced, from the experience I gained in running over many American roads, that the longer and the heavier the carriage the better it rides and the easier it goes round curves at fast speed, and I consider the American 75 to 80 feet long coach is safer and runs better at high speed than does the English one which is only 69½ feet long over buffers. Indian railways therefore are in error in building their coaches 50 to 60 feet long for fast mail service. We should, I think, follow American practice for the best mail trains, and it looks as if I was wrong in having adopted 55½ feet for the new E. B. S. Railway bogie stock, but, at the time, this was the longest of the designs submitted to me.

84. It rather struck me that the public and the railways concerned were now placed at a disadvantage by the Pullman Company, which has become a monopoly, and many men would, I fancy, like to see the carriages owned by the railway companies themselves. The charges made by this Company are twice as great, if not more, than those levied in England, and passengers are rather arbitrarily treated. Thus it is the rule that even if a top berth be unoccupied it must be let down, and no separate berths or accommodation for ladies are reserved even at night-time. Then the carriages are hot and stuffy and they will take no luggage under the seat, and the windows are made hard to open.

85. There is more decoration, veneering, and plate glass than comfort in them, so I think, and I should not wonder if in time the latest English practice for "sleepers" will have to be adopted, and a separate compartment with lavatory with no top berth will be supplied for one or two persons. At most two people should be put in one compartment for the night, and with the 10 feet width and a side corridor, this could, I think, be comfortably managed without top berths. In the day-time this compartment ought to be able to seat four people. One scarcely appreciates the inlaid work on the bottom of a top berth when one is lying on one's back in the bottom berth and shut in by heavy curtains.

Pressed and Cast Steel Cars and Bolsters.

86. On the 25th April I visited the Pressed Steel Car Company's Works at Pittsburg which give employment to about 10,000 workmen and turn out from 100 to 108 steel cars a day; each car, say a pressed steel coal or ore car of 100,000 lbs. capacity, taking three days to complete, painted and ready to put on the road from the time the steel plates or bars are first handed over to the Shearing Department. All work is done by piece work, and the rush and push in the shops is something surprising. A pamphlet describing the operations of the Company accompanied by a book of photographs of some of the most suitable-types of cars accompany this Report as Appendix N., and personally I should be very glad to see a hundred or so of these cars, designed to the dimensions recent and best for India ordered with a view of actually testing their merits. The weight of live load per foot run compared with existing best practice in India should be the factor in deciding on their merits. For comparison the following dimensions might be taken as a fair average:—Weight per foot run of train of American loaded coal hopper wagons, 33 feet long over buffers and holding 110,000 lbs. would be 4,394 lbs., weight per foot run of live load 3,333 lbs.; E. I. R. R.'s coal

wagon :—Length over buffers about 24 feet, load 17·5 tons, tare 6·5 tons, weight per foot run of train 2,148 lbs., weight per foot run of live load 1,625 lbs. If the Indian wagon however is only 23 feet over buffers, the freight per foot run would be 1,704 lbs. Thus the American coal train carries per foot run about twice as much as the Indian one which runs on a wider track.

Bearing this in mind I have not the slightest doubt myself that if the B. N. R. or the E. I. R. employed the American wagons for their coal traffic to Calcutta, and if the Port Trust were able to mechanically unload them at the Kidderpore Docks, as they should do, the railways concerned and the traders too would never go back to the four-wheeled type of wagon for the Indian coal traffic. The life of the steel wagons is put at 25 years as a minimum.

87. Electric power motors for each machine or batches of machines and pneumatic tools of all sorts as well as electric cranes and pneumatic hoists are used largely in the new shops.

88. At St. Louis I visited the office of the Shickle, Harrison and Howard Iron Company, who do a very large business in freight and engine tender trucks, but I had not time to visit their works. I submit (Appendix O.) copies of pictures of the trucks, bolsters, and body bolsters made by them, and statements setting forth the results of recent test undergone by them and I have further detailed drawings if required. Their trucks are said to be lighter than pressed steel ones and the Company also claim that they stand the effects of corrosion produced by carrying coal better than pressed or built up steel work. Their work was highly spoken of by several roads who used their bolsters and trucks.

89. On the Rock Island & Pacific R. R. they were using pressed steel bolsters supplied by the Pittsburg Company as also cast steel trucks and bolsters from St. Louis, and also composite malleable iron and built up steel trucks and body bolsters. The Superintendent of Terminals and the Superintendent of Transportation of the Central Railways of New Jersey told me at Jersey City that they had 1,000 coal and ore pressed steel cars, and that they gave every satisfaction. In fact every railway man who had used the steel cars was pleased with them, and the only doubt expressed was if they would stand the action of sulphurous coal.

90. In America cars are not cleaned out so carefully as we treat them in India, and it was thought that the action of rain and moisture on the sulphurous coal would soon wear out the steel, but I was able to tell them that experience in India with steel cars had not shown them to be excessively susceptible to damage from this cause.

91. There were two classes of pressed steel coal and ore cars I found in use on the B. & O. R. R. Each was 33½ feet long over buffers, but one car a little higher than the other; one carrying 10 per cent. over 95,000 and the other 10 per cent. over 100,000 lbs. capacity; the former weighed 35,000 and the latter 37,000 lbs. All these were hopper cars, unloading at the bottom. The steel gondola cars made by this Company generally have bottom unloading arrangements, but some have none, and some again have end doors, and some all fixed sides and ends, but of course these details can be made to suit the customs of each country.

92. At the Buffalo Exhibition the following cars were exhibited by the Pittsburg Pressed Steel Car Company, it being understood that 10 per cent. in excess of the capacity shown is generally put in them.

(1.) One high hopper car for coal or ore, capacity 100,000 lbs., tare 30,200 lbs., length over buffers about 24 feet.

(2.) One high hopper car for coal, capacity 80,000 lbs., tare 34,700 lbs., length 32 feet.

(3.) One gondola hopper car, capacity 80,000 lbs., tare 33,000 lbs., length 37 feet.

(4.) One platform car, capacity 10,000 lbs., tare 29,000 lbs., length 41 feet.

Cast Iron Wheels.

93. For freight trucks, nothing else is used in America, the tread being chilled, and almost everyone I met told me that they were perfectly satisfied with them, and declared that there are few breakages or accidents with them. In fact the P. R. R. go so far as to use them for nearly all their passenger and tender trucks, and most other railways do the same. The Rock Island & Pacific R. R.'s Locomotive Superintendent spoke strongly in their favour, and the general opinion of nearly every one I consulted was that they were quite safe and entirely satisfactory. They were three times as cheap as steel wheels. In many cases all but the main driving wheel of freight engines are made of cast iron centres. The same opinion was given me by the Locomotive Superintendent of the B. & O. R. R. where they were used by his road for all freight cars, for engine tenders, and for many passenger coaches. For very high speeds however cast iron or cast steel centres with steel tires are used on this and most other railways. The P. R. R. officials I found however were not quite sure that the cast iron wheels under the modern heavy coal and ore cars were strong enough, as they had recently had a number of breakages in wheels under the cars, but they were the only persons, except the officials of the B. & A. R. R. who had doubts on the subject. The Locomotive Superintendent of the B. & A. R. R., which was the last railway I went over, however, told me that they did not themselves use, nor did they allow any passenger vehicles to run over their line with cast iron wheels, as they did not consider them safe.

Workshops.

94. Through the courtesy of the Carriage Superintendent of the L. and N. W. Railway, I took the opportunity before going to America of making several inspections of that Railway's carriage shops at Wolverton. These shops are perhaps as up-to-date as any in England, and I was much struck with the transformation that is going on in the supply of power. Some shops are now fitted up with electric power, a dynamo either driving each machine or a group of machines or else driving a line of shafting and extensions now under erection are being arranged for using electric power only.

95. Electric cranes are superseding steam cranes, whilst pneumatic power is also largely used for light work, such as hoists, drills, shears, screwing and rivetting machines, hammers, etc., and I was assured that the new power, either electric or pneumatic, was cheaper than the old, it being easier to control. There was also a large electric light plant and repairing shop, as for all extensions of the lighting for carriages, where otherwise increased gas lighting plant would be required, electric light is being supplied. Stone's system is being used and I was told that it gave general satisfaction and required little repairs. Its capital cost per vehicle was, however, said to be twice that of oil gas fittings, whilst its weight was one-third more

96. On the 27th of April, I inspected the head workshops of the Illinois Central Railway, 13 miles from Chicago. Only repairs were carried out here, as all engines, carriages and wagons were purchased. Electric cranes are used, but not much electric power, whereas in the C. and N. W. R. R. workshops at Chicago, nearly everything is done by electric power. However, the round house (engine shed) turn-table was worked by electricity. The most interesting tool I saw in use was the mechanical blacksmith worked by pneumatic power. The heavy one worked at 125 lbs. pressure

with a 21-inch cylinder and forged valve yokes and any stuff up to 1 cwt. in weight, pressing and forging articles of all shapes, whilst the small ones forged links, hooks, and all small blacksmith's work. The saving effected was said to be considerable, and I think it is the best labour saving machine I saw and is eminently suitable for India.

97. I was shown the latrines in the workshops where the excreta was incinerated by flames and heat from a furnace passing over it and below the seats, it being all reduced to dust and blown up the tall chimney. The furnace was placed at one end of the row of seats and the chimney at the other.

98. *U. P. R. R.*—The Divisional Superintendent, Wyoming Division, U. P. R. R., told me they were beginning to use electric power extensively in their Omaha and Cheyenne workshops.

99. On the 6th May, I visited the Rock Island and Pacific workshops in Chicago, in company with Mr. Wilson, the Locomotive Superintendent. The work has outgrown the existing shops, and they are to be enlarged and remodelled and electric power is to be largely employed. Pneumatic hoists and drills, etc., are extensively used, and Mr. Wilson considered that electric power would replace steam to a large extent in American workshops.

The round house was of the usual circular shape as on the Madras Railway, and the Locomotive Superintendent stated, and this was corroborated by officials of all other lines that it was very rarely indeed, if ever, that the turn-table got out of order and blocked in the engines.

100. On the 13th May I visited the Baltimore and Ohio workshops at Baltimore, and only that morning they had just put up and started working a 60 horse-power motor to work some 22 machines in all in their maintenance of way repairs shops. They have in the boiler shop two electric cranes capable of lifting 100 tons between them. Electrical power is to be largely utilised, and the power is obtained from their electric railway power house 1½ miles distant.

Pneumatic power is very largely used for hoists, hammers, rivetting and drilling machines, as also for dusting and cleaning the upholstering of carriages. The compressed air, at a pressure of 80 lbs., is supplied by an Ingersoll compressor using 900 c. f. of air per minute.

101. In their workshops they were constructing their own freight cars, the trucks, truck and body bolsters being made up of malleable cast and wrought iron, the bodies and underframes being of wood. They weighed 29,000 lbs. and were to carry 60,000 lbs. The Assistant Locomotive Superintendent said the St. Louis firm's cast steel bolsters and trucks had given every satisfaction, the only cases of fracture being due to accidents. They had in use 3,000 of the Pittsburg pressed steel cars, and had ordered 2,000 more. Whilst satisfied with the result of their working, he showed me that they had discovered several weak places and defects in their construction which were being remedied, and there is no doubt that the rivetting and some of the putting together work done at Pittsburg is too quickly and carelessly carried out.

P. R. R'.s Workshops at Altoona.

102. These are very fine, and I spent a whole day going over them. It was exactly the same here as at Wolverton on the L. and N. W. Railway. Electricity was being substituted for direct steam-driven machinery in many shops, motors being employed for very heavy machines, such as turning axle, etc., and for all extensions motors were being largely used. I was told that, on account of the easy control of the generation

of the current, automatic governors controlling the output, electric power was likely to be cheaper than direct steam. Pneumatic power was also largely employed. I was shown a double-headed axle lathe whose output was comparatively as seven to five of the single machine, one man superintending two axles being turned at one time in the one machine. The chilling of the cast iron wheels, which is done by means of a cast iron chill mould, extends to three-fourths of an inch inside the tyre.

103. The best types of engines shown me were the passenger E.2, Atlantic type, pressure 205 lbs., and the H. 6, eight-wheeled coupled freight engine, pressure 185 lbs. Both types are simple engines, the P R. R. not using compound engines, of which they only possess about 10, as they consider the best pattern compound has yet to be designed.

Mr. Ely told me that coal was so cheap with them that economy of fuel was not a great incentive on the P. R. R., and that whilst believing that compounds had an advantage of 15 to 20 per cent. over simple engines in respect of economy in fuel, the former cost more to keep up and repair. In days past they had tried Webb's and Vauclain's and many other systems.

104. I saw two labour saving appliances in connection with an ashpit. The pit was deep enough to let a small hopper car run on a light track under the engine. The ashes from the latter were scraped into it, and it was then hoisted by an overhead pneumatic hoist, and the contents delivered into a wagon on an adjacent track. Another was the supply of sand to the sand box of an engine just as water would be delivered through a crane, the sand being forced up and out through the nozzle by air pressure.

105. Another very clever machine I saw working was a panelling machine which, by a pantograph mechanism, carved out roughly the decoration work in four wooden panels at one operation. Nearly all the carved work in relief is done in this way, the cutting tools being worked by flexible shafting.

106. Two of the best labour saving and cleverest machines I saw in America were at work in these shops. They were respectively the bolt-threading and the nut-tapping machines. In the first the bolts were simply thrown into a moving pan at the top, when they automatically sorted themselves and worked down a channel, held up vertically by their heads until they were seized in a sort of a vice, and a cutting tool rose up and cut a thread on them, and out they were shot one by one on the floor. One machine turned out 800 ½-inch or ⅝-inch bolts per hour, but the inventors were at work on a 1-inch machine. The nut-tapper was even cleverer. The nuts were simply put anyhow into a moving receptacle at the top, whence they tumbled into a revolving disc, and by centrifugal force they were thrown into four channels which led them one by one into positions where rising and falling tappers cut threads in them, when they were thrown out. At present nuts up to ¾-inch diameter were being treated. About 600 an hour were tapped, and this machine would do 3½ kegs of bolts (1 keg=1,800) in 10 hours, versus the old style of machine, which only did one keg in 15 hours. One man could easily look after four machines at once. The patentees were the Acme Machine Company, of Cleveland, and the machines had only been working a few months. I believe they are now being exhibited at the Glasgow Exhibition.

I also saw an older pattern 10 spindle revolving nut-tapper, which turned out 10 nuts at a time.

107. I saw for the first time two men employed in re-painting with a pneumatic and paint spraying machine the big pressed steel hopper coal cars, and these men painted 12 to 15 cars a day inside and outside, and it was said they did them at half the cost of

brush painting, and the paint was spread over them thoroughly into the joints and crevices and difficult places where a paint brush would find it very hard to go. The paint was contained in a small tank on wheels, the air being conveyed to the tank through a hose, and the two were mixed and anatomised in one part of the machine, the paint leaving the nozzle in an anatomised spray. I was told that actually there was a saving in paint by this process. The pressure employed was 85 to 95 lbs. The invention should, I fancy, be useful and successful in India for steel wagon painting or very rough work.

108. I was also interested in a patent window sash which was said to have been in use for two or three years, and to have given much satisfaction.

The sash had its upper end connected to a strong cloth curtain or band, which band wound round a roller provided with a spring, just as the spring blind does. On squeezing a latch on the bottom sill the window rises and is kept up at any position. To let it down the latch is pressed, and the window moves down almost by its own weight. The patentee is Edwards, of Syracuse. It struck me as worthy of extensive trial. The Locomotive Superintendent of the B. and A. R. R. also told me he liked it and was going to try it.

109. The pneumatic broom is extensively used for cleaning carpets and upholstery, and I believe it would blow most of the dust out of Indian carriages, and it is actually used at the Schenectady Electrical Works for blowing the dust out of armatures, dynamos, etc.

110. The car bolsters used by the P. R. R. are obtained from the Pressed Steel Car Company, and have given satisfaction. The railway company then makes up the truck, using malleable iron and steel for the rest of the work.

111. I visited the Boston and Albany R. R.'s workshops at Allston, which are 12 miles from Boston, accompanied by the Locomotive Superintendent of the line. Electric and pneumatic appliances are extensively used for hoists, cranes, aad for running machines and all kinds of tools, and the pneumatic broom is used for cleaning carriages, carpets, and upholstery. The Locomotive Superintendent also had fitted up two trains with pure acetylene gas, which had been running satisfactorily since September last between Springfield and Albany. I inspected one of these trains in Albany Station, and I am able to attach a description and ferrotypes of the plant (Appendix P.). Each carriage had its own generating plant, which was fitted into a cupboard or small compartment at the side of one of the cars. The instalment for 20 burners in a 60 feet car weighed 250 lbs. only, versus of 1,800 lbs. given me as the weight of the plant for Pintsch's system. The existing gas pipes can be used, but no reservoirs are required, and the closed globes must be abandoned for ordinary coal gas open globes. Those used were small white ground glass globes with porcelain shades. The light was brilliant and steady; there were 12½ hours supply of full lighting, 25 lbs. of carbide being used in the generator. This produced 125 cubic feet of gas, and each burner consumed half a cubic foot per hour. The system is said to be absolutely safe, the pressure of the gas never rising beyond 1½ lbs. A car cleaner looks after the plant at the termini, no attention being required for the running journey. The light can be turned down to a pin's point either at the lamp or for all the lamps at the main valve just like Pintsch's gas. At present carbide costs 3¾ cents. a pound, but the price will grow less. The Locomotive Superintendent said the burner difficulty had been got over, and gave as an example the case of a beacon light used by the United States Government near New York, which had burned without requiring cleaning for 604 continuous hours, and the Company were going to supply one to burn 40 days and nights continuously without the burner being touched. The difficulty is got over by well scrubbing or cleaning the gas. He hoped to provide all additional lighting on the

line by acetylene, using Pintsch's gas for the carriages now in use. Only one director's car had been fitted with electric lighting on the line, and American railways, so I was told, are awaiting developments before changing their present gas plants.

Since my return from America I have spent a fortnight in a house fitted up with Acetylene gas. The installation for 60 burners with ordinary fittings cost 130*l.*, and the light was most satisfactory. Carbide cost 1*l.* per cwt. and the consumption for a maximum supply was about 15 to 20 lbs. per diem. I still think, however, that the most sensible thing to be done in India is to mix Acetylene with Pintsch's gas as recommended in the Report of the Indian Delegates to the last International Congress.

Compound engines were extensively used by the B. and A. R. R. for freight engines and had given every satisfaction.

112. *The Schenectady Company's Locomotive Workshops* at Schenectady, near Albany, were visited by me on the 6th June, the Superintendent showing me round.

113. They are the second largest private engine workshops in America, and do very good work, and are extensively patronised, especially by the N. Y. C., the B. and A., the N. Y. N. H. and H. and the N. P. Railways. Electricity and pneumatic power are largely used, and the former has just been installed in a new shop where a 500 horse-power generator has been erected. The Superintendent gave me the following information :—For American roads, steel boilers and fire-boxes with wrought-iron tubes are always ordered. Most freight engines use cast-iron centred wheels, except for the main driving wheel, but steel wheels are beginning to be preferred by some roads. The cast iron produced in America is of good quality, the breaking strain for that used in cylinders being from 25,000 to 29,000 lbs. per square inch.

114. The highest pressure used by engines turned out of these shops is 210 lbs. One-fourth of the engines constructed, mostly for freight service, are of compound design, called the Von-Boiies, or cross compound type, with a high pressure cylinder on one side and a low pressure on the other, the pressures being usually 200 and 100 lbs. Piston valves are chiefly supplied. The Northern Pacific, however, who are having 150 freight engines made, prefer the tandem design, one high pressure cylinder discharging into a low pressure one being placed on each side. The N. P. R. R.'s engines weigh as much as 185,000 or 200,000 lbs., and the tenders 90,000 to 100,000 lbs.

115. At Schenectady I also visited the General Electric Company's workshops, one of the largest in America, and in which I saw orders being executed for the New South Wales and Mysore Governments. The works are very fine and absolutely up-to-date, the only steam engines used being those employed in one power house as auxiliary steam power generators, which, in case the turbine plant, 18 miles distant up the Hudson breaks down, can be used for the works as well as for running the street cars in the town. The voltage at the Hudson is 11,500, and falls to 10,000 at the works, and 1,500 horse power is utilised. This voltage is usually reduced by transformers to 250 volts for use in the several machine motors. Everything is worked by electrical power, even a gantry with 40 feet span and an overhang of 15 feet, lifting over 20 tons, running about the yard like a tramcar, it being actuated by a motor.

In some cases, long lines of belting were run by one motor, but as a rule each machine had a motor, and some were of 15 horse-power. Where found convenient, planing and drilling machines weighing 20 tons each were lifted by electric cranes and dropped into position and then clamped to the floor. In some cases, the work rotated or was moved by motors, and the tool was fixed; in others the tool and workmen rotated, and the work was stationery. Pneumatic tools were everywhere in evidence, and

curious to say they were considered better for small work than electrical power, as they weighed less. It was the finest display of electrical power I have ever seen, and the work seemed to be very high class.

Watering and Coaling Engines.

116. On some of the railways, such as the P. R. R. and the B. & O. R. R., which have direct connection with the mines, and at places where much coal filling of tenders has to be done, the coaling of the engines which use the two goods tracks lying between the two outside passenger lines is done from an overbridge from small trucks which discharge the coal straight into the tenders through a shoot. It only takes two minutes to fill a tender. Water also is often supplied in much the same way from a 12-inch overhead crane suspended from a bridge, and it takes only 1½ minutes to fill a 6,500-gallon tank. The U. P. R. R. water crane is 10 inches diameter only.

117. To save labour and time nearly all railways run their hopper coal waggons up a wooden trestle and unload their coal through the bottom doors into bins holding 40 tons or more each, which bins shoot their contents sideways into the tenders of engines standing on tracks on each side below. The coal practically trims itself by running into conical shaped tender receptacles, and it only takes from 1½ to 2 minutes to fill a large tender with coal. The door in the side of the bin is arranged to slide open, being controlled by a balance weight, or is opened round a hinge, and the apron is also hinged at the bottom of the bin and is hauled up or down by men on the tender below, so that the coal can run over the apron into the tender. It is quite possible time and money might be saved even in cheap labour India by adopting American practice in large locomotive yards.

Coal Unloading Plant.

118. At the New Jersey termini of the P. R. R. I saw the 100,000 lbs. capacity steel hopper coal cars being unloaded into barges. The trucks were run up a wooden inclined trestle and the bottom doors were then opened and the coal fell out into shoots and slide into the boats. The tare of the waggons was from 37,000 to 39,800 lbs., their length over buffers being only 33½ feet. These cars are nearly always loaded to 110,000 lbs, a 10 per cent. excess in loading being generally permitted on all American railways. Lighter cars than these, however, are built for other railways by the Pressed Steel Car Company, some of which weigh only 35,000 lbs. to 37,000 lbs., and which carry the same load of 110,000 lbs. The wooden coal gondola weighs about 31,600 lbs., and carries 60,000 plus 10 per cent. of coal, whilst the steel gondola weighs 30,000 to 33,000 lbs, and carries 80,000 lbs. plus 10 per cent.

119. When at Baltimore I visited, with the Superintendent of the line, the coal loading plant at the docks. The work is done in the same way as at Curtis Bay, a great coal export harbour of the B. and O. R. R., some 10 miles further down Chesapeake Bay. At the Baltimore Docks there was a wooden pier running out into a basin in deep water with three lines of rail on it, the two outer being working lines and the centre track being for empties.

120. On each side of the pier vessels could lie and at the time I was there a schooner for Boston, of 3,500 tons capacity, was being loaded with coal. It was being filled from four shoots at a time, one shoot being provided for each car. A barge of 1,700 tons had just been loaded in 2½ hours.

121. The method of working was as follows :—Some six 110,000 lbs. capacity cars were pushed up the inclined approach of the pier by a switching engine until they stood on the level opposite and above the ship. There, eight men, earning 20 cents an

hour as wages, took possession of a truck and opened the bottom doors, whereupon the coal fell between the track into a shoot and shot straight into the hold of the vessel. It only took $1\frac{1}{2}$ to $2\frac{1}{2}$ minutes to run the coal out, and then the wagon was hauled forward by a horse, unhooked and let run back to the "empties" line by gravity. I omitted to say that there was a weighing-machine on each outer track which recorded at one operation the tare and gross weight of the truck. The wagon was in its place on the empty line in less than five minutes from the time the engine pushed it into its unloading position, and it is difficult to conceive anything more simple and inexpensive and less unlikely to get out of order. The B. & O. Railway officials were certain that it was cheaper and could do far more work than any tipping machinery, and the only drawback is the rough usage the coal undergoes in dropping from the mouth of the shoot over the hatch to the bottom of the hold, but I was told that to a large extent the breakage is being avoided at Curtis Bay by an arrangement under which the stream of coal in the shoot is held up until it arrives close to the point of deposit. The coal under shipment by the B. & O. is a soft bituminous coal and resembles very closely that found in the Bengal coal fields.

In the hold of the schooner there were 60 men told off to trim the coal, and it is this work which limits the speed of loading, and it is quite possible such work could be better done by an electric trimmer.

122. But even allowing for the delay in trimming, 500 to 600 tons of coal were being put on board per hour, and at Curtis Bay, where there is one large pier 800 feet long, berthing two vessels on each side, and possessing 24 coal shoots on each side, three to four hundred 50-ton cars are dealt with per day of 10 hours. At the wharf in Baltimore, where I inspected the loading, two hundred 110,000 lb. cars were ordinarily dealt with in a day of 10 hours.

The General Superintendent of the B. & O. at Baltimore estimated the cost of transferring coal from car to ship at certainly not more than two cents a ton (one anna), this rate not including interest on the capital cost of plant.

123. When at Philadelphia, the P. R. R. officials described their arrangements in the harbour as being similar to those at Curtis Bay; they had also a similar plant at Amboy, where half the coal handled is hard and half soft.

124. On the 22nd May I inspected the coal loading plant on Lake Erie of the B. & O., the Erie and the P. R. Railway Companies. The plant is owned by the Pittsburg and Chicago Coal Company, and Mr. Donaldson, the Manager of the Dock and Fuel Department of that Company, as well as representatives of the B. & O. and P. R. R. Companies, accompanied me.

125. All the coal is dealt with in basins or canals leading from Lake Erie, and the first installation I saw was that of the B. & O. R. R., which I will call No. 1.

No. 1.—The coal cars of all sizes and kinds are run by gravity down a low inclined trestle past the coal dumping plant, and are then attached to a small dummy car and hauled back by wire rope on to a cradle in between the legs of a steel staging. The cradle is elevated by wire cables operated by a steam engine, and can be raised 50 feet or any height required. The car is clamped in position, and after rising to the required height is quickly turned over sideways, so that the coal runs into a pan or funnel-shaped shoot, and from there runs through a telescopic shoot or mouth attached to the pan into the boat. The pan, which can be raised or lowered by chains, hinges on the side towards the water, and can be turned up with the shoot nearly vertical, or let down to any required angle. The shoot has three telescopic parts, and can be operated separately and be directed to any any part of the hold, and be held vertically or otherwise, and in some cases it is provided with a door to hold up the coal. The

mouth of the telescopic shoot is kept resting on the coal already deposited in the hold and is raised a few inches and the coal above it then let out when and where required, thus avoiding breaking the fuel; each car load, after the first, has therefore only a few feet to slide before it deposits itself on the coal in the pan. It only takes 2½ minutes to raise a car, unload and return it to original rail level, and each empty car is pushed off the cradle by the next full car to be dealt with.

At a pinch 25 cars can be handled in an hour, but owing to the delay in trimming the coal in the ship an average of 20 cars an hour is only dealt with. The cost per ton is put at two cents without and four cents with trimming, the interest on the capital cost of plant not being taken into account.

126. Only three men are employed, *viz.*, an engineer, a fireman and a shoot man. The cost of trimming, which is done by hand, is 2 to 2½ cents. a ton, and the vessel has to be moved along to get its full load. There is absolutely no escape of oil from the axle boxes as the tipping of the car is done in a moment.

127. No. 2.—At Ashtabula, I was informed that 1,000 tons an hour were dealt with, as the latest design permitted of two 30-ton capacity cars being handled on one cradle, and these then tipped into a pan. This pan is then raised to the height required, and the coal slides out of the bottom of the pan into a similar shoot as described in No. 1. The cost is the same, whilst the speed is a little greater, but the coal is more liable to be damaged as it is separated twice.

128. No. 3.—The P. R. R.'s plant is exactly similar to No. 1, only there is no telescopic shoot. The coal slides down the pans and shoot at the one and same inclination, and the consequence is that the vessel has to be moved in and out from its berth along which it lies, and the trimming is more expensive.

The cars in the case of this plant run direct on to the cradle by gravity, and when unloaded run off by gravity and go up a small incline to a bumping block, and are then switched back on to the down-grade empty line. This was the first side-dumping machine put down on Lake Erie. The cost of loading is much the same as in No. 1.

129. No. 4.—Here there was a very high inclined trestle where the cars, which must be all hopper type, were hauled by means of a cable and a dummy car, and the coal was shot into eight pockets holding 700 tons each, just as the coal is dealt with in filling locomotive tenders. The doors of the bins or pockets are then opened, and the coal slides through long shoots into the holds of vessels. Three hundred tons an hour were put on board, but this plant is only used for fuelling vessels.

130. No. 5.—The Erie R. R.'s plant consists of very high trestle, and a switching engine pushes a car into a hollow iron cylinder, and the car is then automatically clamped by hydraulic pressure on the top and side nearest the water. The cylinder is then hauled by ropes worked by a steam engine, and revolves, working its way up an inclined plane, the coal slipping into a pan and shoot as described in No. 1. The pan is at a fixed height, and does not move up and down as in No. 1 design. The trestle work is very expensive, being 32 feet above water level. A vessel of 7,000 to 8,000 tons can be loaded in one day. The cost is much the same as in No. 1. This was the first plant put down at Cleveland and is objectionable in that it requires a location where a high trestle can be erected. A vessel of 3,000 tons was being loaded in six hours, including trimming.

131. No. 6.—A plant at Fairport was described to me perhaps suitable for India in so much as it is an end tipping system, the cars all having end doors. The incline and the shoot form one piece and are in one plane, and after the car has been run on

to the incline, the latter, as well as the shoot, both of which are at one inclination, are tilted over, and the coal runs down the pan and shoot into the hold. The objection is that there is no reserve held up, and the coal is damaged, each car load being dumped straight through the shoot at every operation.

No. 7.—At Buffalo I was told the hard coal is run up an incline and put into pockets, and then shot through shoots into ships at the rate of 5,000 tons in three hours, each pocket holding 700 to 800 tons.

132. The Manager of the plants seen by me told me that, if faster trimming could be done, or if boats could be shifted quickly, or if he could deal with an 18,000 ton boat, he could, with most of his plants, do 18,000 tons a day, by which he meant that that was the capacity of each machine as far as simply emptying the wagons was concerned. He showed me drawings of a new invention of his which he thought better than any other, and this would only cost 12,000 to 15,000 dollars, and would load regularly 600 tons an hour. The car, which would be received on a trestle 12 feet high, must be a hopper wagon, and it emptied into an inclined pocket below, from which it was elevated by a band and buckets into the pan and shoot described in No. 1. If the wharf were 15 feet above water level, he said that no trestle would be required.

133. At Cleveland last year the coal handled by the Company amounted to 4,000,000 tons.

134. As regards the question of unloading coal from vessels into wagons, a subject of considerable importance in India, the system adopted at the Lakes was described to me as follows:—There is a long transporter or inclined girder on trestles at right angles to the wharf alongside of which the vessel lies. The coal is dug out by a dredger, something like the one we use in India for well-sinking, and this when lifted catches on to a trolley and is hauled back over the wagon by a winding engine, and when emptied it runs back to the vessel by gravity. The wagons are placed on sidings parallel to the wharf's side, and 10 or 12 of these dredges or skips work at the same time in one vessel. Each skip can do 500 tons a day, and thus 5,000 to 6,000 tons can be shifted during daylight. The patentees are the Webster Camp and Lane Company, Akron, Ohio; the McMyler Manufacturing Company, Cleveland, and the Brown Hoisting and Carrying Company, Cleveland.

135. This matter of coal unloading is a very important subject for India, especially for Calcutta, and I offer the following remarks, because, having been a member of the Committee of the Port Trust, I advised Mr. Cable, of the firm of Messrs. Bird & Co., before he returned to India, not to overlook the probability of bogie wagons having to be dealt with at this port, and I was one of those who strongly advocated mechanical coal unloading plant being put down at the earliest opportunity at the Kidderpore Docks.

136. It appears to me to be difficult to come to any other conclusion but that the coal traffic of India, which is still in its infancy, should be dealt with in bogie cars of large carrying capacity. This is especially important in respect of coal booked to Calcutta for export. There do not seem to be any great difficulties in the way, such as exist in older civilised countries, where coal screens, sidings, weigh-bridges, turn-tables, hoists, and terminal plant were designed for handling small wagons, but even in Great Britain recent discussion at the Institution of Mechanical Engineers (*see* the Proceedings for October, December 1900) was in the direction of acknowledging the advantages and feasibility of dealing with this class of traffic in large trucks in Great Britain as is done in America. In fact, one of the largest dealers in the coal export trade in the North of England spoke strongly in favour of the big capacity car for coal, and predicted that all new harbour works would provide plant for handling the large wagon. It is

well known how limited are the terminal facilities in Calcutta and Kidderpore Docks, and how expensive all additions must be, and hence the saving of siding room, berth space, and consequent increase of capacity for handling effected by the use of bogie stock, seems to point to the paramount necessity of making any coal exporting plant erected at Kidderpore suitable for dealing with the largest sized bogie stock. As a rule, Indian open wagons are provided with too low sides, and particularly the coal wagons of the E. I. Railway. High-sided trucks, as supplied to State lines and as used in America, seem preferable for coal and general traffic.

137. After seeing the plants in use in America, I am convinced that coal can be dealt with mechanically in Calcutta at the same cost as in America, provided large-sized capacity cars are used, and the E. I. and the B. N. Railways and the public would never return to a small wagon if they once tried a big one.

Grain Elevators.

138. I inspected the P. R. R.'s elevator at Jersey City. Most of the cars dealt with are from 60,000 to 80,000 lbs. capacity, and two men with shovels worked by chains will empty an 80,000-lb. capacity car in half-an-hour. From the bin the grain is lifted by vertical belts fitted with scoops, and after weighment at the top the grain is shot into other bins; these bins then discharge by shoots wherever required.

139. At Baltimore I inspected one of the two large elevators of the B. & O. R. Railway, one of these being the largest of any on the Atlantic Coast. Along one side of the elevator lay the "Bethania" of Hamburg, a vessel holding from 10,000 to 13,000 tons, and this vessel was being filled with wheat, the loading to be completed in one day. Four shoots only were working, but the elevator, if fully working, could employ 11 shoots on each side at the same time. The leather driving belt for turning the shafting was 5 feet wide and 325 feet long, and reached from the ground to the roof, and the horse-power of the engine was 1,000.

140. The large elevator could hold 1,800,000 and the smaller 1,500,000 bushels, and 225 cars of about 30 tons capacity per diem could be dealt with by the large elevator. The only handling the grain undergoes is done by the two men in the car, who, by means of the rope-assisted shovels, scrape and guide the grain through the side doors into the shoot of the bin below the car.

141. The charge made for transferring the grain to the ship and storing it for 10 days is 1¼ cents. a bushel, and the accounting for the grain is kept in the following way:—Anyone delivering grain for export would have it examined in the wagon in the yard near the elevator by surveyors from the Chamber of Commerce, who would grade it according to class, such as No. 1, No. 2, etc. The grain is then put through the elevator, where it is weighed, and after that it is mixed with anybody else's grain of the same grade, the railway company only accounting to the owner for so much grain of such and such a grade.

Heavy Passenger and Goods Engines and the Loads behind them.

142. On the 19th April, the General Manager of the N. Y. C. R. R., in the presence of Mr. Dudley, their Inspecting Engineer and author of Paper No. 1, read at the Paris Congress, gave me a photograph of their most powerful goods engine (Appendix Q.), and told me that two days previous a similar engine hauled between Syracuse and Albany, a distance of 150 miles, 94 cars weighing 3,783 American tons, the capacity of most of the cars being from 60,000 to 80,000 lbs. The engine is an eight-wheeled coupled compound with pony truck and boiler pressure of 200 lbs., weight on driving

wheels 164,000 lbs. and on bogie truck 26,000 lbs. Its cylinders are 23-inch+35-inch × 32 inch, and diameter of drivers is 63 inches. Total weight 190,000 lbs. without tender and about 136 tons with tender. This train was some 3,600 feet long and the sidings between the main track where such trains have to be crossed have to be made nearly one mile long.

143. Again, on the 20th April, the General Superintendent of the Terminal Division of the P. R. R. at Jersey City, told me that the P. R. R. every day practice was for an engine to draw 2,500 gross tons of grain and 3,000 gross tons of coal cars on the level portion of his road, and some of the trains I passed on my way to Baltimore the same day were enormous in length, and were actually of this weight.

144. Exactly the same thing happens on the B. & O. R. R., the gross weight, however, only rising to 2,700 tons, on account of the steeper grades.

145. On the 10th May, the Superintendent of Transportation and the Superintendent of Terminals of the Central R. R. of New Jersey told me that in the summer time, on the level portions of their line, one engine often hauled 3,200 tons, and I myself saw trains of 50 to 80 cars on my way to Baltimore. In fact, on the level, where the loads can be obtained, loads of from 2,000 to 3,500 gross tons are common practice on lines East of the Missisippi.

146. I am able to attach a statement, marked Appendix R., giving all particulars of engines on the P. R. R. It will be seen from this that the latest type of passenger and goods engines marked in the list have the following dimensions:—Passenger engine, Atlantic type, with 200 lbs. boiler pressure; weight on drivers 100,695 lbs., on bogie truck 36,335 lbs., and on trailing wheel 32,320 lbs.; total 169,350 lbs.; cylinder 20½-inch × 26-inch.; diameter of driving wheels 80-in.; tender 90,000 lbs.; heaviest axle load 51,105 lbs.

Goods engine, H. 5 Class:—Four-wheeled coupled and pony truck; weight on truck 20,800 lbs., weight on drivers, 175,700 lbs., total weight 196,500 lbs.; weight on tender 100,600 lbs.; boiler pressure 185 lbs.; diameter of driving wheel 56 in.; cylinder 23½ in. × 28 in.; heaviest axle load 45,600 lbs.

The pressure worked to by some of the latest engines, such as the G. Class, is however 225 lbs.

147. The book of engine ratings of the P. R. R., furnished as Appendix S., is most interesting, and is as good an example as can be required of the enormous loads hauled on certain sections of this Railway, and is typical of what is done every day on the P. R. R., and on the N. Y. C. R. R. and some other roads which deal with a large ore and coal or grain traffic. The Pittsburg and Erie R. R. also daily run trains with one engine having a gross load of 4,000 tons behind the engine, and on the 22nd May I saw such trains working.

148. This P. R. R. rating book shows that after deduction of the "loss by resistance" the gross load behind one of their most powerful engines on certain sections is 3,200 tons. On account of the shortness of some of the sidings, which are only 3,600 feet long, trains are usually limited to 86 cars, and when I was travelling with the General Manager of the P. R. R. I saw more than one train of this length, and he told me that one engine had hauled into Conway Yard, the great sorting yard just West of Pittsburg, with 35 miles of sidings, a train 6,200 feet long and weighing 4,200 tons. passed a loaded goods train of 93 box cars, and an empty train (a few loaded were in it) of 103 cars. On my return from Pittsburg to Philadelphia I passed several goods trains hauling on the level or down grades 2,700 tons.

149. When at Altoona and Philadelphia I was told that the H. 5 Class, practically similar to the H. 6 Class, constantly pulled 3,300 tons on the level, and one, some little time ago, hauled an experimental train 132 miles from Altoona to Harrisburg at an average speed of 10 miles an hour, the train weighing 5,212 tons. These are facts as given me by Mr Ely, the Chief of Motive Power, himself.

150 On the 28th April, the Colorado special that took me from Chicago to Salt Lake was composed of seven vehicles 75 to 80 feet long and weighing 300 tons. The C. & N. W R. R. engine attached to it was Atlantic type; pressure 200 lbs. and weight on driving wheels 104,000 lbs. Another vehicle was added 150 miles from Chicago, and often there are nine coaches on the train; average speed 34 miles—road fairly level.

151. One of the Illinois Central R. R.'s best type of passenger engine is a four-wheeled coupled machine with leading bogie, and they make, with the N. O. Ltd., the run between New Orleans and New York, 912 miles, in 25 hours, or an average speed of 36½ miles.

152. The heavy freight engines with six wheels coupled, and a pony truck, work at 185 lb. pressure, with 145,500 lbs. on the drivers; the weight on pony truck is 21,700 lbs.; total weight 167,200 lbs.; total with tender 314,800 lbs. They carry 7,000 gallons of water and 15 tons of coal. These engines only take water once in their 128 miles run from Chicago, and they haul about 2,200 gross tons.

153. I submit (Appendix T.) a ferrotype book giving particulars of all their engines. One heavy freight engine they have is an eight-wheeled coupled type weighing 184,800 lbs. on the drivers, and total weight with tender 308,400 lbs.

154. The Missouri Pacific passenger engine I saw at St. Louis ready to start with its train was a six-coupled type with four-wheeled leading bogie truck. Boiler pressure 200 lbs., and weight on drivers about 120,000 lbs.

155. The C. & N. W. R. R. six-wheeled coupled freight engine hauls 60 loaded or 90 empty cars.

156. The Union Pacific R. R. passenger engine hauled nine coaches between Council Bluffs and Julesberg, a distance of 375 miles, at a speed of 43 miles an hour, and two of them hauled this load up the mountain pass beyond Cheyenne over grades of 90 feet to the mile. The U. P. R. R.'s. best passenger engine was a six-wheeled coupled one, with a four-wheeled bogie truck in front; pressure 200 lbs.; compound system; cylinders 15½ in. + 26 in. × 28 in. stroke; weight on drivers 142,000 lbs.; total weight exclusive of tender 184,000 lbs. The compound freight engine is six-coupled and pony truck; cylinders 15½ in. + 26 in. × 30 in. stroke; pressure 210 lbs.; weight on drivers 161,000 lbs.; total weight 185,000 lbs.; in working order with tender 300,000 lbs.

157. They haul at an average speed of 23 miles 1,400 gross tons or 2,000 tons at slower speed. An experimental train run last year was one mile long and weighed 10,000 gross tons or 149 cars on a down grade. The distance run was 102 miles, and the trial was satisfactory. All this information was given me by the Divisional Superintendent of the Wyoming Division with whom I travelled, and he stated that less than 10 years ago his railway did not haul more than 500 or 600 gross tons.

In fact, the great advance made in weight of trains has all been accomplished in the last 10 or 12 years, so several leading men told me.

158. On the Denver & Rio Grande R. R., on a heavily graded line just south of Salt Lake City, I passed a train of pressed steel cars carrying coal weighing 1,700 tons. The engine hauling it was an eight-wheeled coupled one.

159. At Minturn, just west of Leadville City, to haul the six-car train over grades of 1 in 25, where an elevation of 10,400 feet was obtained, we had two Mogul type engines.

160. On the Burlington, Missouri R. R. the train I travelled by to St. Louis weighed 400 to 450 tons, consisting of ten 75 feet cars, and it did 929 miles at an average speed of 36½ miles an hour over an indifferent road.

161. The engines used were six-wheeled coupled, with leading four-wheeled bogie truck; weight of engine 103 tons; tender 27 tons; boiler pressure 200 lbs. Non-compound, with piston valve gear, the latter being very largely used in America. Appendix U. gives ferrotypes ot their best classes of engines.

162. On the Rock Island & Pacific R. R., an engineer I met told me that in September 1900 he and a friend timed a train which was behind time, and it ran between two stations on a level piece of road 11 miles in 13 minutes, counting, starting and stopping. The engine was Vauclain compound type, and had 7 feet drivers, and it hauled 13 cars. This type of compound engine is very much fancied in America.

163. I visited the Rock Island & Pacific R. R. workshops on the 6th May, and their Locomotive Superintendent showed me the latest types of engines which he considered suitable for their road of some 4,000 miles long, the ruling gradient being one per cent. and this very common—their loads consisting chiefly of cattle, grain, and provisions. Westward, up the grades their freight engines hauled 1,000 tons (gross) trains, but down the grades they often hauled 2,000 tons.

164. Their type of passenger engine was a four-coupled Atlantic machine, with a four-wheeled leading bogie truck and a trailer. This was for fast traffic averaging 50 miles between stations, and it hauled from 9 to 13 coaches averaging 100,000 lbs. each. Weight on drivers was 97,000 lbs.; on truck 39,000 lbs., and tender 37,000 lbs.; total 173,000 lbs.; boiler pressure 200 lbs ; fire grate 74 in. x 108 in. inside dimensions. The tender carried eight tons of coal and 6,500 gallons of water. Action simple.

165. One such engine had lately hauled seven cars 182 miles between Rock Island and Chicago in 3 hours 18 minutes from start to finish, equal to an average speed of 55¼ miles. The heavier type for slower passenger trains was a Vauclain compound with piston valve gear. It was a six-wheeled 78 ins. diameter machine, with a four-wheeled front bogie truck; boiler pressure 200 lbs.; weight on driving wheels 133,000 lbs.; on truck 40,000 lbs.; and tender 110,000 lbs. It sometimes hauled 15 cars.

166. The freight engine was a six-wheeled coupled engine. with a four-wheeled bogie in front with 20 in. x 28 in simple expansion piston valve engine; pressure 200 lbs.; fire box 72 in. x 120 in.; weight on drivers 130,000 lbs.; on truck 40,000 lbs., and tender 110,000 lbs. Tender 5,500 gallons. It could haul 1,000 gross tons up the grades and 2,000 gross tons down or on the level.

Its fast goods traffic of 1,000 gross ton train was hauled 1,080 miles from Denver to Chicago at an average speed of 25 miles from start to finish.

167. On the Central Railroad of New Jersey, the Transportation Superintendent I met at Jersey City told me that they hauled in the busy summer season 3,200 tons gross with a simple engine working at 200 lbs. boiler pressure. The engine weighed 105 tons without its tender, the weight on the eight driving wheels being 83 tons. He also stated that two engines, by way of experiment, had hauled a train of 4,400 gross tons up a grade of 22 feet to the mile. I append also (Appendix U.) four ferrotype diagrams of the Chicago, Burlington & Quincy Railroads engines. Their Atlantic type

passenger engine is of the following dimensions:—Total weight, with tender 258,450lbs.; weight on drivers 85,850 lbs.; weight of engine 159,050 lbs.

168. Their heavy freight engine is an eight-wheeled coupled type, with pony truck; weight on drivers 165,650 lbs.; on truck 15,000 lbs.; total 180,000 lbs.; with tender 274,850 lbs.; boiler pressure 180 lbs., but 200 lbs. is preferred.

169. Another freight engine is a six-coupled one of the following dimensions:—Weight on drivers 130,500 lbs; weight on front truck 14,200 lbs; on trailing wheel 25,400 lbs.; total weight 170,100 lbs.; with tender 286,700 lbs.; boiler pressure 200 lbs.; cylinders 20 in. x 24 in.

170. I submit also, as Appendix V., a ferrotype book of the B. & A. R. R.'s engine. Their road has 53 per cent. of curvature, and maximum grades of 1 in 82.

171. I attach, as Appendix W., ferrotype diagrams of the best types of the Baltimore & Ohio Railway engines. Their passenger engines carry from 3,000 to 5,000 gallons of water and from 4 to 8 tons of coal, whilst their freight engines carry 6,000 gallons and 8 tons respectively. The freight engines most fancied are the Vauclain compound type with piston valve motion. There are a high and a low outside cylinder on each side of the engine with cylinders 15½ in. + 26 in. x 30 in. stroke. Boiler pressure is 200 lbs.; weight on the eight-coupled drivers 165,000 lbs., and with pony truck 183,800 lbs.

172. The simple compound engine is practically of the same weight and dimensions, but works with 190 lbs pressure. Its cylinders are 22 in. x 28 in. with a 54-inch wheel. The weight on the drivers is 153,700 lbs., and weight on pony truck 15,000 lbs.

173. The best passenger type is a six-wheels coupled compound engine of the following dimensions:—Cylinders, 15 ins. + 25 in. x 28 ins., weight on drivers 114,800 lbs., and weight on leading truck 41,200 lbs.

174. Another type is a compound Atlantic four-wheeled coupled engine with cylinders 15 in. + 25 in. x 28 in; weight on drivers 83,400 lbs., on leading truck 37,940 lbs., and on trailer 28,260 lbs.

175. The big freight engines draw trains weighing 2,700 tons eastward into Baltimore, the line having many gradients of 43 feet to the mile (1 in 123). If it were level these engines are said to be capable of hauling 4,000 gross tons. The east-bound loads between Cumberland and Brunswick (102 miles) are 2,750 tons, but as soon as the grades are improved and heavier rails put down it is hoped to haul 3,200 tons from Cumberland right into Baltimore (175 miles).

176. On the B. & O. R. R. on the mountain grades I passed one train of 70 empties weighing 1,100 and one of 60 coke waggons going eastward and downhill weighing 2 500 tons, also another of 45 pressed steel cars weighing 2,700 tons.

177. The Locomotive Superintendent gave me 70 tons as the average gross weight of a loaded ore or coal pressed steel truck in a train, and 45 to 50 tons as the average weight of a grain-loaded car forming part of a train.

178. I give on the following page a memorandum handed me by the Divisional Superintendent of the N. Y. C. & H. R. R. at Albany on the 7th June. He was just about to despatch the information to his General Manager, and it should dispose of any idea that my notes exaggerate facts.

179. The figures make one's mouth water, and set one thinking why India with its 5 ft. 6 in. gauge should not go one better.

"Memorandum showing the Numbers of Engines, Number of Cars, and Tonnage of East-bound Freight Trains on the Mohawk Division of the New York Central Railroad between Syracuse and Albany, from 8 A.M. 4th June to 8 A.M. 6th June:

	Tons.
Engine 1758, 62 cars	2,652
" 1744, 68 "	2,726
" 1779, 68 "	2,208
" 1709, 66 "	2,692
" 1569, 53 "	1,790
" 1705, 59 "	2,652
" 1752, 60 "	2,647
" 1771, 67 "	2,773
" 1730, 64 "	2,703
" 1713, 70 "	2,587
" 1710, 67 "	2,760
" 1715, 73 "	2,668
" 1786, 68 "	2,744
" 1784, 68 "	2,348
" 1778, 68 "	2,395
" 1735, 68 "	2,649
" 1727, 69 "	2,538
" 1690, 54 "	1,721
" 1781, 71 "	2,260
" 1775, 75 "	2,627
" 1745, 66 "	2,049
" 1731, 73 "	2,503
" 1730, 62 "	2,348
" 2332, 80 "	3,336*

These trains were hauled over maximum grades of 18 feet. Where the grades exceed that amount, helping engines would be used."

180. I also give three typical performances of main-line freight trains, as usually run over the Mohawk Division of the N. Y. C. R. R., east bound, in May 1901, as furnished to me the day before I sailed for England:—

Case No. 1:—

Loaded cars	91
Train mileage	140
Helping mileage over grades	18
Total weight of lading	1,884 tons.
" " " cars	1,089 "
" " " lading and cars	2,973 "
Per cent. of lading to total weight of train	63·3 per cent.
Average lading per car moved	20·7 tons.

Case No. 2:—

Loaded cars	85
Train mileage	140
Helping mileage over grades	14
Total weight of lading	2,437 tons.

* 100 engines of this type have been ordered.

Case No. 2—*contd.*	
Total weight of cars	1,288 tons.
„ „ „ lading and cars	3,725 „
Per cent. of lading to total weight of train	65·4 per cent.
Average lading per car moved	28·8 tons.
Case No. 3 :—	
Loaded cars	82
Train mileage	140
Helping mileage over grades	14
Total weight of lading	1,896 tons.
„ „ „ cars.	1,238 „
„ „ „ lading and cars	3,138 „
Per cent. of lading to total weight of train	60·4 per cent.
Average lading per car moved	23 tons.

181. The average freight in a freight train, including both loaded and empty cars on the N. Y. C. R. R. system is as follows:—

On all lines and branches, 398 tons.

On all main line trains, east and west bound, 794 tons.

The average load of all loaded freight cars is 15 tons.

182. As regards the question of the merits of the American compared with the English locomotive, no doubt the American engine burns more fuel and wears out sooner, and the former is unquestionably a dirty looking machine, but as Mr. Ely put it to me, Americans do not design their engines for looks, nor do they expect them to last more than 15 years, by which time they are ready to put them on the scrap heap and adopt a different design and a more efficient article; and it must be remembered that coal is extremely cheap in America. My admiration for them is based on the work they perform, and their great hauling capacity makes up for any defects in their details. I am afraid we do not scrap weak and out-of-date engines often enough in India.

183. After all, the first duty of an engine is either to run fast or to pull a big load, and I would sooner have a dirty looking engine that would haul 3,500 tons than a beauty to look at that could only haul 600 or 700 tons as in England, or 1,200 tons as in India. The cost of coal is only one factor in the cost of carrying a unit, and the E. I. Railway would be better, if, with its cheap coal, its engines hauled American loads, even if its coal consumption per engine mile were doubled and its engine had to be scrapped at the end of 15 years. To say that Americans could not build just as nice looking an engine, or put just as good work into it as English manufacturers do is a statement I could not accept after having seen their tools and machinery and methods of work. As a matter of practice, American lines, so Mr. Ely told me, like to run an engine for all it is worth, provided traffic is offering, just allowing sufficient time for cleaning and repairs, and some of his engines he said did 15,000 miles a month. Their dirty looking engines, moreover, keep remarkably good time.

Through Speed of Goods Trains and Duty of Wagons.

184. The speed is greater than in India. For instance, on the P. R. R. the General Manager told me that fast cattle trains would average 20 miles an hour between Chicago and New York, a distance of 960 miles; other fast trains, such as fruit or vegetable or packed meats doing 16 miles an hour, and this with 50 to 60 loaded cars. An ordinary goods wagon would take five days for the trip or an average of eight miles an hour, or 192 miles, against 145 miles on the N. Y. C. R. R., whereas in India our goods wagons travel some 90 miles only during each 24 hours from start to finish, chiefly because Indian Administrations, for some not very good reason, tie up their

trains at every engine changing station. The U. P. R. R. told me that they move the whole of their freight cars on an average 40 miles a day, whilst the through speed for their fast trains was 25 miles an hour.

185. The General Superintendent of the B. & O. at Baltimore told me that their fast freight trains took 60 hours between Chicago and New York, a distance of 1,016 miles, and average 600 tons behind the engine. An average speed time for an ordinary goods train between Chicago and New York might be taken at 200 miles a day, the train actually running 20 to 25 miles an hour between stations and the load averaging 1,700 tons.

186. The Train Master of the N. Y. C. R. R., Hudson Division, told me that to clear the line on their busy section they had to run goods trains on that division at 30 miles an hour between stations, 45 to 50 trucks being hauled at this speed.

But very heavy goods trains, however, do not, I believe, average more than 10 miles an hour between stations, and, as before stated, I am not an advocate of great speed. What the Americans accomplish is the hauling of a huge load—say of 3,000 tons—at a speed equal to that at what we haul 1,200 tons in India, and the result is achieved by using immensely heavy and powerful engines.

187. The average daily duty of all wagons on some of the railways was said to be as follows:—N. Y. C. R. R., 23 miles; U. P. R. R., 36; C. & N. W. R. R., 42 miles.

Brakes.

188. Over 60 per cent. of American goods stock is automatically braked, and in Russia, all goods stock is to be similarly equipped by January 1905.

I found the opinion general in America that it is on the whole economical to automatically brake all stock, and I endorse the suggestion made in the report on the Paris Congress that Indian railways should gradually provide automatic brakes for all vehicles. I, myself, believe that this expense will have to be faced by all important lines and that ultimate economy will result, particularly where heavy trains have to be hauled, but no doubt the initial expense will be great and the work will have to be spread out over a number of years.

189. An interesting discussion on the application of brake power on trains will be found in the Minutes of Meeting of the New England Club, submitted with this report (as Appendix X.). Were not most goods vehicles braked in America, their heavy trains would be unmanageable and dangerous to handle.

190. American railway engineers now consider that it is good practice to brake the bogie truck wheels as well as all the driving wheels of engines. I find I made a mistake in my report on the Paris Congress in saying that experiments were being made in applying the break power to the inside of the rims of the wheels. This is not the case. What I should have said was that it is becoming a common practice to suspend the brake shoes between instead of only outside the wheels of trucks, there being one shoe to each wheel of a truck. Some people think this is an improvement on the old practice and has less tendency to tilt the vehicle, but the opinion seems to be divided as to the merits of the new practice.

Gasolene and Oil Vapour Engines.

191. These are very much used in America, either for giving power, generating electric light, raising water, etc. They can be run with any of the products of petroleum, such as kerosene, gasolene, naptha, etc., or with illuminating gas, either that of coal or

mineral oils, or with natural or acetylene gas. Where liquid fuel is used it is vaporised in the machine and then mixed to form the explosive combustion. The pressure in the cylinder is generally from 40 to 60 lbs. Pintsch's gas, as used for gas lighting, or this gas mixed with acetylene, can also be used, and such engines might be given a trial in India for the purpose of raising water, generating light, or giving mechanical power, as the same machine can be turned to many uses, and it is quite safe and simple to work. They could, for instance, be used for compressing air for pneumatic interlocking, or for driving machines or cleaning carriages by air blast. The efficiency of the gas engine is said to rise to nearly double that of a steam engine, and Americans consider that for small installations they are the cheapest motors extant. The application of oil vaporising engines for use as motors on automatic cars would also seem to be practicable in India, where kerosene or petroleum is fairly cheap, and such automotor cars might possibly be usefully employed on trunk roads as feeders. The opinion seems to be gaining ground that when its cost is reduced carbide of calcium will be an ideal portable fuel for a gas engine.

192. The Divisional Superintendent, Wyoming Division, U. P. R R., told me they used gasolene engines extensively as auxiliaries to the windmills to raise their water.

193. The N. Y. C. & H. R. R. authorities told me that they used gasolene engines extensively for raising water, working the belts of mechanical coal-elevating plants, and for compressing the air for working pneumatic drills, reamers, and rivetters, the compressor and the gasolene engine being on one frame.

The Boston and Albany Railroad also use gasolene engines extensively for raising water. They were also used for motor cars for the track supervisors on the N. Y. C. R. R., some 20 being in use. The cars were three-wheeled ones weighing 325 lbs. and made a speed of 20 miles an hour. The third wheel takes off, and the car can then be loaded into a baggage car.

Advantages of Increasing the Capacity of Goods Stock.

194. Some of these advantages are referred to in paragraph 4 of the Indian Delegates' Report on the last International Railway Congress. To my mind these advantages cannot be over-stated. Good designed rolling stock has always seemed to me to be the main factor in successful and economical working, bad stock taking 20 years to replace, and hanging like a millstone round the neck of the unfortunate possessor, and it is greatly to the credit of the India Office and the Indian Railway Administration that this important point has not been overlooked in India. The whole of the reporters to the International Congress recognised its importance, and it is to be regretted that the only countries, as represented by their reporters, who argued against taking action and showed luke-warmness in the matter of improvements were Great Britain and Australia.

195. There can, however, be no doubt that the difficulties in the way of increasing the revenue compared with the non-revenue tonnage, must, sooner or later, be faced by British railways, especially as the mineral traffic on British railways forms 72 per cent. of the whole business of the companies, and at any rate a start can be made by renewing old stock, both that of the railway companies and private owners, with either stock of similar dimensions, or of such sizes as can be used without causing serious alterations to existing turn-tables, weigh-bridges, sidings, coal shutes, terminal arrangements, etc. Some British railways, in spite of the apathy of the public to this subject, are already beginning to supply stock of larger capacity, and I am convinced that trade necessities will sooner or later force such improvements on all British railways and wagon owners. I would go further and predict that the only way by which British railways can prevent their dividends steadily dropping and effect large ecomonies in working, thereby giving a share of the benefit to the railway and a share, by reduction of present excessive rates, to the public, is by building larger and better wagons, some four-wheeled,

some bogie, and by altering wholly or partially the turn-tables, weigh-bridges, sidings, terminal arrangements, etc., which are now alleged to be an insuperable obstacle. The live load can certainly be increased by raising the height of the sides of ordinary sized wagons and by enlarging the dimensions of the axles, and, as one writer suggests, private wagon owners might be encouraged to improve their stock by basing the charge on the gross weight instead of on the live load of their wagons. A perusal of the reports presented to the Paris Congress will show that many European Continental railways, in spite of the attendant difficulties, have already begun to improve the design of their stock, and are building four-wheeled stock with a load capacity of 15 to 20 tons.

196. To show that this is possible—and what is possible on the foreign and English lines must be easily possible on the Indian standard gauge—the G. W. Railway has constructed, and is using, a four-wheeled mineral wagon of 20 tons carrying capacity, of 8 tons 6 cwt. tare, which is about 20 feet long, 8 feet wide, and 4 feet high, with journals 10 in. × 5 in. Its wheel base is 12 feet, compared with 8½ to 9 feet of the ordinary wagon. A photograph and a ferrotype of the wagon is appended (Appendix Y.), and it will be noted that the Locomotive Superintendent states that this size of wagon can be used with the existing facilities at the various works and collieries which these wagons serve.

197. The L. & N. W. Railway has also built two trial mineral wagons of 20 tons capacity of which the dimensions are as follows:—21 ft. × 7 ft. 9 in. × 4 ft. 2½ in., with 10 in. × 5 in. journals, the tare being 7 tons 18 cwt. For purposes of comparison it may be noted that the inside dimensions of an E. I. Railway low-sided wagon are about 19 ft. 4 in. × 9 ft. × 2 ft. 9 in., with journals 9 in. × 4½ in. The Caledonian Railway has even gone so far as to build some mineral bogie wagons of 50 tons capacity, the inside dimensions of which are:—34 ft. 7 in. × 7 ft. 7 in. × 4 ft., and they are now going to make trials between some pressed steel cars ordered in America and some from the Leeds Forge Company. The G. W. Railway is also using bogie rail wagons of 40 tons capacity and 17 tons 7 cwt. tare.

198. With these examples before one in Conservative England, it is open to discussion if the present best type Indian broad gauge low-sided four-wheeled wagon carrying 17½ tons, cannot be improved upon. With higher sides, stronger axles, and an increase of axle load, better results seem quite possible of attainment, and surely it must be worth trying to beat the Americans, who, with their hopper coal cars, as mentioned in my notes on pressed steel cars, actually carry in their bogie vehicles twice as much coal per foot run as the best Indian type railway wagon does.

199. To show what competent practical wagon builders think can be done with British stock, Mr. W. R. S. Jones, late of the Indian railways, recently made the following statement for the information of the members of the Institution of the Mechanical Engineers of Great Britain.

200. He said that a steel wagon only one foot longer than a N. E. Railway coal wagon of 10½ tons capacity and measuring 17½ ft. × 7¾ ft. × 4½ ft. could be built to tare 5·7 tons and carry 15 tons. Allowing a similar expansion of traffic as has taken place in the past, *viz.*, about 56 per cent. in 20 years, he calculated, that if the additions and renewals were carried out in accordance with the new type and the operation were credited with only one of the gains, *viz.*, a saving in locomotive haulage of 35 per cent., the railways and private owners would at the end of the period be 80 million pounds in pocket above what they would have had to spend in continuing existing practice in wagon building. This result would have been obtained with a saving of five and one-third million tons in dead weight and a saving of 45·7 per cent. in siding room. This comes to 15 per cent. less end-to-end space than the present stock of wagons now required. Bearing this in mind, I might perhaps be allowed to make a prediction, and that is, that the combined system of the G. I. P. and I. M. Railways, with its magnificent

geographical position, will see days of great prosperity if it follows American practice when renewing and adding to its goods stock, for it is a well known fact that the trucks of the G. I. P. Railway have in the past been the worst revenue-earning vehicles in India and have seriously retarded its progress.

201. Another point of importance that was brought out during the discussion at the Society's meeting was the baneful effect that private owners' wagons had on trade. Even if the difficulties connected with the improvement of the design of traders' wagons could be got over, the empty running and the limit to which such trucks can be used for general traffic makes them most expensive for railways to work. Unfortunately, English railways use some 500,000 traders' wagons out of their total of 1,167,000 trucks, whilst India has none, and it is to be hoped that any outcry against Indian Companies on the score of short wagon supply will not result in the introduction of traders' trucks.

202. To come back to English practice, it is open to question if weight is not often improperly sacrificed to speed, and I think that merchants and consumers will eventually find it to their advantage to encourage the railway companies to haul heavier trains at slower speed and for a lower charge, except for special classes of traffic.

203. I would now refer to the paper in question, No. 18 of the Paris Congress, by Mr. Loree, President of the American Railway Association, and General Manager, Pennsylvania Lines West of Pittsburg (Appendix Z.) Nothing can be more convincing than the proofs he adduces on pages 67 to 71 of the advantages of large cars, although I think, in the case of India, it would be prudent to introduce only a percentage of large bogie cars according to the nature of the traffic on each railway. Mr. Loree shows on pages 67 to 68 (note that the table on page 67 is incorrect as regards the 20,000 lbs. capacity car, which however does not affect his deductions), that although the haulage of 1½ tons additional dead weight for each 80,000 lbs. compared with a 60,000 lbs. capacity car, involves for its average mileage per annum an excess expenditure of $23. 10, one journey of 857 miles with an additional load of seven tons over the average load of 10 tons, makes things equal, and he shows further on that a fair percentage of the bigger cars carry a high percentage of their marked capacity. The General Manager of the P. R. R. at Philadelphia told me that they had found that if an engine could haul 2,000 tons with 60,000 capacity cars, it would haul 2,300 tons with 100,000 lbs. capacity vehicles.

204. Whilst thinking that it is not proved that either a metre gauge or a 5 ft. 6 in. bogie wagon taken by itself must necessarily have a better revenue percentage of capacity than a four-wheeled vehicle, still there can be but little doubt that the other advantages of the bogie design as enumerated on page 71 of Mr. Loree's report, must exist, and it is the great saving of siding room and other capital expenditure, the greater handiness of short trains, the smaller resistance to traction, the saving in interest on first cost per ton of capacity of cars, and the saving in wages from the decrease in number of trains hauled that constitute the superiority of the bogie over the four-wheeled vehicle. It is worthy of note that all the American railways, replying to Mr. Loree, are unanimous on these points, and it must not be overlooked that the first American railways started with a 7,000 lbs. capacity four-wheeled and 10,000 lbs. capacity eight-wheeled truck.

205. On page 68, Mr. Loree puts the cost of moving a gross ton a mile at nearly a pie, that of the paying load being about two and two-fifth pies, whilst the average receipts on the P. R. Railway are slightly over three pies per ton per mile (the rupee being taken at 1*s.* 4*d.*), and he states that it is due to the adoption of the bigger car that American railways have been able to reduce the cost per ton mile to a figure thought impossible several years ago.

206. That this is so is a fair assumption when the advantages of the big wagon are combined with the economy gained by hauling immense loads in one train, and it is for

these reasons desirable that Indian railways should not be satisfied with existing practice, good as it certainly is, but should experiment with a view of adopting a proportion of the best type bogie stock, with extra strong axles, and the heaviest engines found by trial to be safe to run on the road.

207. I think also that careful trials might be made with a view of ascertaining once for all the resistance to haulage of similar weights of trains, one composed of four-wheeled and the other of bogie trucks. The L. & N. W. Railway Carriage Superintendent says that he has proved by actual trials that the bogie vehicle is decidedly lighter in haulage. Another point for consideration is whether axle loads might not safely be increased. The P. R. R. actually goes up to 19,000 lbs. per wheel rail-load for their heaviest cars, and their engine axle loads are as much as 22¾ tons; and the N. Y. C. R. R. 23 tons, English practice having got as far as 20 tons. As much of the P. R. R. and N. Y. C. R. R's. track is no stronger than that of an average Indian trunk line, the present moderate limits of 15 tons for an engine axle load and 12 tons for a wagon, are open to criticism. I am certain axle loads will have to be increased some day, and pending the laying down of a heavier rail, the road might certainly be strengthened by adding sleepers.

208. From inquiries I have made, it is believed that the pattern of coupling supplied to Indian railways for several years past is capable of standing a much heavier stress than it now experiences, and where weaker couplings exist, the wagons so equipped could presumably be attached at the rear of the train.

209. It cannot be denied that many of the Indian railways could get loads to fill long trains, a large proportion of their traffic consisting, as is the case in America, of heavy cheap commodities, such as grain and seeds, sugar, coal, salt, stone, and many other bulky articles, and if America with the 4 ft. 8½ in. gauge can haul 3,000 to 3,500 gross ton trains, there seems to be no good reason why the Indian 5 ft. 6 in. gauge railways with their strong roadway and bridges cannot do the same. At any rate they might try, and if they succeeded, as I firmly believe they will, their financial success will be phenomenal.

Metre Gauge Stock.

210. It will be noted that my remarks generally refer to the English gauge of 4 ft. 8½ in., or the Indian standard gauge of 5 ft. 6 in., but they are also applicable to the metre gauge which is pre-eminently suited for bogie practice. The metre gauge lines in India, forced by necessity to justify their existence, have been the pioneers of good practice in both carriage and wagon building, and from the commencement have largely adopted bogie designs. Its permissible axle load on the rail has risen from four to seven tons, and its rail section from 36 to something over 50 lbs., but if it were allowed a nine ton axle load, and were provided with stronger axle and a 60 lb. rail, it would never be beaten by the best broad gauge practice, and it would achieve even greater success than it has won in the past.

Rates and Fares and Cost of Carriage, etc.

211. I attach to this report a pamphlet entitled "Do American railways pay?" (Appendix a.), and, although opinions may differ respecting the author's views on the subject of Government ownership and supervision of railways, his deductions not being sound, so I think, in the case of Indian railways, still the statistics compiled and the results attained as given by Mr. Car-Skaden are of the greatest interest to those concerned in the economical and successful working of railways. He shows that the average charge per American ton mile for goods for all America was, for 1898, ·785, and for 1890, ·927 cents. At the present rate of exchange, these work out to about five and six pies respectively per English ton, and these rates are probably approached by those in India where, for 1899, the charge averaged slightly higher. For the E. I. Railway and the A. B. Railway, however, they were 4⅗, and 3·65 pies respectively.

one being due to the phenomenal cheapness of coal and level grades of the railway, and the other to the desperate and unprofitable competition with river traffic. These charges are exceptional however, and for the broad gauge all round they might be put at an average of six or seven pies. The author also shows that the average passenger rate in America is about two cents (12 pies) per mile, that for India for the year 1899 being about 2½ pies.

As regards the cost of carrying a unit a mile, this information is difficult to get, as statistics are only published for one or two lines, and I was assured that American railways in order not to give such States as exercise control over rates and fares a lever to use for further reductions, naturally prefer not to show too good result. Very keen competition, too, acts as an inducement not to disclose too much, but it is only fair to assume that a railway like the Pennsylvania, earning big dividends and in first class condition, would not carry a huge mass of its traffic, such as coal, ore, and grain at a charge of a quarter to one-third of a cent per American ton per mile (1½ to 2 pies), as I am told it does, unless it could do so at a profit, say at a cost of 1¼ to 1½ pies. The cost, therefore, as stated in Poor's Manual, *viz.*, 2·13 pies, is likely to be much above the mark.

212. I was told that President Hill of the G. N. Railway, who is considered to be an authority on the subject, put the cost per American ton 6 cents (3·6 pies) east of the Missisippi and 1 cent (6 pies) west of that river. For all America I see the Railroad Gazette places the charge for 1899, at·724 cents, say 4½ pies per American ton, but the Vice-President of the St. Louis Terminal Railways and Wabash Railway told me that often in competition east of Chicago and St. Louis the rates for coal and ore and steel to the Coast went down to ·25 cents, and this rate was sometimes applied to grain.

213. Whilst the rate, *i.e.*, the charge, depends on many factors, such as the capital cost of the property, competition, wealth of the population, etc., the cost is a very good criterion of the methods of working, and the keen competition, the scarcity and high cost of labour and the necessity for working economically in order to give some profit on the large capital outlay involved, have resulted in America in a marvellous exhibition of successful railway operation. It is these conditions which have produced the enormous engines, cars and train loads, and the reduction of handling to a minimum, and it is because India, whose goods traffic conditions somewhat resemble those of America, has worked much on the same lines, that her railways now come next to America in the matter of cheap rates and cost of working. It is, however, to be hoped that India will not be satisfied with what she has done, but will see if her train loads, both for passengers, but more especially for goods, cannot be still further increased.

214. I may be wrong, but to me, there seems no good reason why in India grain and seeds should not in time be dealt with in Elevators, be hauled in long trains in cars of large capacity, and be carried in bulk to Europe. And if salt also could be carried in bulk, as I think Punjab rock-salt could be in the dry season, there would be mutual advantage to the railways and the public, and the cheapening of this universal article of food would benefit millions of consumers.

215. I admit that to attain similar results to those exisiting in America, axle loads would probably have to be increased, and all I would suggest is that if such important advantages can only be obtained by increasing the axle loads, then a bold policy in this direction should be adopted, and the proposal should not be rejected on theoretical grounds without trial. It would be easy in case of failure to bring down the axle, loads of those wagons that have given offence and to alter or even discard the few engines used for the trial. But with the strengthening of the bridges that has taken place over nearly all the trunk lines of India, and with a 100-lb. rail for the broad gauge, which section I recommend elsewhere for renewals, it is doubtful if a moderate increase of

axle loads would have a deleterious effect. It may be noted that it is stated that the wheel load on the rails for American 60,000, 80,000 and 100,000 lbs. capacity cars comes to five, six and eight tons respectively, the maximum permissible in India on the broad gauge being six tons.

216. I give below a table of comparisons between some American and Indian roads.

Table of Comparisons.

Name of Railways.	Gross Earnings per Mile per week.	Average Rate per Passenger per Mile.	Average Rate per Ton per Mile.	Average Expenses per Passenger per Mile.	Average Expenses per Ton per Mile.	Average Haul of a Ton of Goods.	Average Distance travelled by a Passenger.	Cost of Coal per Ton of 2,240 lbs.
	Rupees.	Pies.	Pies.	Pies.	Pies.	Miles.	Miles.	Rupees.
B. and O.	1,076	10'14	2'76	—	—	199'4	36'1	2'88 to 6'25
Lehigh Valley	890	11'16	2'46	—	—	174'4	32'7	—
N. Y. C. proper	1,147	10'16	{ 3'66 / *3'33 }	8'58	2'58	191	29'7	3'12
P. and R.	1,410	9'87	4'92	—	—	66'58	12'52	—
L. S. and M.	8,829	12'57	3'01	—	—	178'5	47'6	—
Chicago and Alton	467	10'52	4'68	—	—	—	—	—
C. and N. W.	427	12'06	5'34	—	—	—	—	—
C. B. and Q.	358	—	—	—	—	—	—	4'69
N. Y. N. H. and H.	1,243	10'62	9'05	—	—	†85'3	†18'11	6'25 to 9'28
C. M. and St. P.	333	14'16	5'82	—	—	—	—	3'91
C. R. I. and P.	348	14'04	5'94	—	—	—	—	—
I. C.	434	11'62	4'17	—	—	—	—	—
Wabash	384	11'74	3'74	—	—	—	—	—
Missouri Pacific	325	12'62	5'08	—	—	—	—	—
G. N.	275	12'78	5'94	—	—	—	—	—
N. P.	326	13'32	6'36	—	—	—	—	—
Chesapeake and Ohio	554	11'64	2'22	—	—	321'9	52'3	—
U. P.	564	—	—	—	—	—	—	4'69
R. G. and W.	356	11'04	7'32	—	—	—	—	4'06 to 4'69
Pennsylvania East of Pittsburg.	1,428	11'59	2'99	6'59	2'13	109	20'7	2'81
Canadian Pacific	201	9'12	4'56	—	—	365'9	117'2	—
B. and A.	1,412	10'68	5'04	—	—	112'05	21'04	7'81
All American railways	406	11'96	4'55	—	—	125'50	26'55	—
Middle States (best lines in America).	858	10'86	3'66	—	—	97'15	19'77	—
‡Pittsburg, Chicago, and Fort Wayne.	1,409	12'12	3'42	—	—	—	—	—
‡P. C. C. and St. Louis	846	12'	3'54	—	—	—	—	—
‡Cleveland and Pittsburg.	1,080	12'90	3'18	—	—	—	—	—
East Indian Railway	637	2'73	4'18	0'75	1'44	206'88	60'05	2'06
B. B. and C. I.	515	2'60	7'00	1'38	3'15	139'82	19'16	16'69
R. M. Railway	266	2'13	6'16	0'78	2'68	217'59	49'11	16'58
B. and N.-W. Railway	133	2'08	4'75	0'90	2'27	115'34	33'62	6'51
Most of lines around St. Louis East of the Missisippi.	—	—	—	—	—	—	—	2'50 to 3'12
Most of lines around St. Louis West of the Missisippi.	—	—	—	—	—	—	—	3'91

* As given me for 1900. † For 1899. ‡ Worked by P. R. R.

217. The statistics for America are mostly compiled from Poor's Manual fo 1898, those for India being for 1899. Figures for 1899 for America were only obtainabl by me after I had made the extracts, but I find they differ little from those for 1898, anc they have been allowed to stand. The earnings per mile per week enable one tc compare the volumes of traffic. It should be noted that American money has been converted at the rate of 1 dollar to $3\frac{1}{8}$th rupees and that the Indian statistics have been reduced to the American ton of 2,000 lbs.

The cost per ton is only given for two American railways, *viz.*, the P. R. R. and the N. Y. C. & H. R. R., but these are the best roads in the country.

The cost of coal per English ton was obtained by me verbally from the best sources available, chiefly from the Locomotive Superintendents of the various lines. The cost is the price paid for it at the nearest station or the nearest junction to the home line.

In looking at the figures in the table it is to be noted that on two American trunk lines, *viz.*, the P. R. R. East of Pittsburgh and the N. Y. C. & H. R. R., whose average grades are no better than those on the most successful lines in India, the P. R. R. being much worse, and with coal at 90 and 100 cents per ton respectively, versus 64 and $46\frac{1}{4}$ cents per ton on the E. I. & B. B. and C. I. Railways, these two American lines carry goods at about 2·13 and 2·58 pies respectively per American ton per mile, and I was told, as before mentioned, and I thoroughly believe it to be true, that in their own interests the American roads are very careful not to show too favourable statistics for the cost of carriage. On some of the busiest and best Indian railways the cost works out to between $2\frac{1}{4}$ and $3\frac{1}{8}$th pies, as for instance, the B. and N. W. and B. B. and C. I. R. R.'s. In the comparison I except the E. I. Railway, whose figures work out to 1·60 pies only (1·44 per American ton), but its coal is phenomenally cheap, costing only $·64 per ton, and its road is practically level throughout, and it has no mountains to climb like the P. R. R. The N. Y. C., however, has a very level road, and here the E. I. Railway shows to great advantage, as it compares as 1·44 to 2·58 pies per ton per mile. What the E. I. Railway would earn with 3,000 ton trains and with a traffic equal to that of the Pennsylvania or N. Y. C. Railways it is difficult to imagine.

218. These comparisons therefore show that on some of the best worked railways in India the cost of moving a ton of goods per mile is already as low as on two of the best and busiest lines in America, the E. I. Railway, with its exceptionlly cheap coal and level road, even surpassing them all. At the same time I repeat the caution that the American figures are purposely cast high. We have also to note the fact that compared with Indian railways the earnings per mile of the principal lines in America are very high, the goods rates it being remembered being low, and the passenger fares high, that coal is phenomenally cheap, but that the lead of goods and passengers is low, notably in the Middle States, with which Indian railways are compared for choice. It shows at the same time that in India the charges to the public, though not exorbitant, average higher than in America. In America they go as low as $1\frac{1}{2}$ pies for ore, coal, and grain, whereas in India the minimum laid down by Government is 2·7 pies.

219. As regards passenger traffic the conditions are very different in the two countries, and the comparison is only useful in showing that where one can get well-filled heavy trains, and provide the least necessary accommodation suitable to the public, and commensurate with the fare, as is done in India, the cost of dealing with it is extraordinarily small. On the whole, therefore, we may conclude that true economy in railway working is obtained by hauling the heaviest possible paying load at moderate speeds, and this applies to both passengers and goods. If India can increase the tractive power of her engines and can haul a bigger paying load in high capacity cars, as I believe she can and will do, she should, owing to the cheapness of construction of her lines and her

cheap labour, be able to charge less and carry cheaper than any other country in the world, and as one much interested in this problem, I think she will occupy this position if heavy rails, increased axle loads, and universally applied automatic brakes, be adopted along with big engines. Her tight couplings and up-to-date details of goods stock, as instanced by her use of carriage springs for goods vehicles, are all factors that help to make the handling of heavy trains and big wagons a satisfactory operation.

220. The following information respecting rates and fares and traffic matters was picked up by me at different times and places:—The fares on the B. & A. R. R. work out to 2¼ cents a mile, but mileage tickets only cost 2 cents. For suburban traffic the fares are from 1 to 1½ cents a mile. Coal and grain are carried at ½ and ⅝th cenths a mile rspectively, but the haul is short.

221. The rates and fares on the N. Y. N. H. & H. R. R. are much the same. That for passengers from New York to Boston for 233 miles was 2·14 cents per mile. I am able to attach a book (marked Appendix b.) containing some statistics of the N. Y. N. H. & H. R. R. They show that the haul on a passenger and ton of goods was 18·11 and 85·36 miles respectively.

The average number of passengers in a train was 68, and of goods 204·11 tons. The traffic is largely suburban in character, as shown by the short average distance travelled by each passenger, *viz.*, 18·11 miles. The Divisional Superintendent of the Albany Division of the N. Y. C. R. R. showed me statistics in which it was recorded that the percentage of empty mileage to total mileage of all freight cars was 31 per cent.

222. On the Denver and Rio Grande R. R., in inter-state booking the rate is between 2 and 3 cents a mile, the rate from Salt Lake City to Denver, a distance of 748 miles, being 2·40 cents. From Denver to St. Louis, by the Burlington Missouri R. R., a distance of 929 miles, the rate was 2⅝ cents per mile.

In the States West of Denver local rates within the States themselves are high, being from 3 to 5 cents a mile, but 2,000 and 3,000 mile ticket-books can be purchased [at a rate of 2 to 2½ cents a mile, and on nearly all Eastern lines, such mileage tickets can be purchased at 2 cents a mile].

223. I may mention that many States possess and exercise control over rates and fares, and many in the east do not permit a fare exceeding 2 cents. To show that States are very careful to keep or get control over rates and fares in America, I attach (as Appendix c.) the 33rd Annual Report of the Boston and Albany Railroad Company for the year 1900. It contains a copy of the lease of this Railway Company to the N.Y. C. R. R., as also a copy of the Act of the State of Massachusets authorising the lease, in which the control of rates and fares over the B. & A. R. R. is clearly set forth and in section 4 it actually insists on rail freights from any point to Boston being the same as to New York and sea freights *viâ* these ports are also to be levied on the same basis.

Baggage System.

224. The check system, no doubt, is excellent for long journeys, and there can be no difficulty in adopting it when and where required, as it consists simply in having duplicate metal numbers provided with straps, one label being hung on the article and the other given to the passenger. But nothing will persuade me that the system is as cheap and convenient or as prompt in action as the English system for short journeys in England, and when America has cheap cabs and labour, passengers, with the aid of a porter, will probably look after their own luggage, and will never let it out of their sight except when it is in the baggage van. I am aware that Americans think differently, but until pilfering of baggage becomes a common practice in England, I can see no necessity for the check system. Express companies in America, according to my painful experien'ce should be severely let alone, and Americans will give you this advice, certainly if you want your luggage sharp. Unfortunately for me, I expressed

my baggage three times from a hotel in New York to one in Baltimore, and on one occasion I could not get it for 48 hours, as it arrived on Sunday instead of the Saturday, and no delivery is made on the Sabbath. On the second occasion I lost it for 27 hours, and on the third I would have had the same experiences, had not an influential Railway official got it through in eight hours, I think all this work had much better be done by the Railway companies themselves as they do in England, and the former should then get more than 40 per cent. of the net profit, which is, I understand, their share now. The public, too, would be more promptly served, and the exorbitant charges would, I believe, disappear. But here, again, the Secretary of the Railway Assocation, with whom I corresponded on the snbject, differs with me, and he thinks that Transfer compainies (not Express companies, whom he says should be shunned for despatch work) do the work cheaply and expeditiously, and he considers that Railway companies could not undertake the work themselves. But I still think the cheap cab will come in America, and, at any rate, until a Transfer company will deliver your luggage at the station nearly as fast as you can get there yourself by a street car, which it does not do now, requiring two or three hours to effect this operation, I cannot admit that the service is satisfactory. We are accustomed in England to make use of our baggage up to the last moment, and it is inconvenient to have to arrange for its removal and make it over some hours before starting for the station.

Rate Works, Differential Rule, Railway Policy, etc.

225. I have purposely said little or nothing about the methods that have been adopted to secure traffic in America. Some of them have not been reputable in the past, and these practices are not suitable for India, as rate wars eventually end in pools, and in the long run benefit no one, certainly not the railways, whilst during the time they are in operation they disorganise business, injure the railways and give play to unjust discriminations. In the case of India, where Government either owns the lines or guarantees the interest on their capital, it has seen, and I have no doubt will continue to see, that inordinate profits to the injury of the country are not made, and it can do this by the mere fact of its possessing the control over rates and fares and by its having the power to use as a lever in its rates policy its State-worked or State-leased lines.

After all a Railway official in India, who acquires a reputation for smartness by simply diverting traffic by quoting very low rates, really deserves little credit, as a large share of any profits of every line in which Government have an interest goes to Government, and all that is accomplished is the reducing of this amount all round for the competing lines, whilst the cutting railway is most likely to come out very little to the good at the end.

As the author of "Do American Railways pay" truly says, "the best way to compete is along the lines of increased efficiency of service, it being a mistaken conception that competition is always the life of trade."

It is the simplest thing imaginable to practice economy at the expense of the road and its equipment and to not get found out during a long period, and credit for cheaper rates and for the better financial results is too easily won, but the time comes when the railway has to spend more, and the line which has neglected to look ahead, and provided a suitable road and rolling stock for improved conditions (and this means spending money, as American railways find out) will most certainly be left behind in the race. It is such an easy and simple thing for the governing body to change the directing staff of a railway if its policy in rates and purely traffic matters do not give satisfaction, or where, for instance, it neglects to utilise to the utmost the good stock and heavy road it may have been provided with; whereas, to take the example of

British railways, we see that the failure to look ahead and adopt a sound policy in the matter of good rolling stock has crippled their earning power, and it will take 20 years at least to equip them with up-to-date good revenue-earning goods stock, and all the administratative talent in the world is now unable to put matters right.

That the rates are high is proved by the fact that some 75 per cent. of the coal and mineral L & N. W. rates (so it was stated at a half-yearly meeting not long ago) are up to the maximum, whilst Mr. Jeans, in his latest Review on the Iron and Steel Industries of the World, quotes the high English rates as the most serious bar to progress.

226. America, on the other hand, is an example of a country that rushed foolishly and sometimes criminally into the making of thousands of miles of unprofitable and uncalled for competing lines, thereby causing unhealthy competition and bankruptcy and ruin to numbers of honest investors.

The saving point about them, though, is, that their magnificent rolling stock and powerful engines in many cases have saved the situation, and the best of American railways, thanks to this and to the policy of liberally spending money on improving their roads, in spite of their high price of labour, are now steadily bettering instead of dim nishing their dividends, whilst English railways' profits are gradually dwindling.

It will be found that the best paying lines and those working cheapest, are those which have spent huge sums in making their roads stronger, and all American railways are finding out that in order to live and be able to work cheaply, their roads must be capable of taking heavy axle loads and accommodating long trains.

227. I would here draw attention to the fact that several of the leading men in the Operating Department informed me that the differential rule for charge was fairly strictly observed in America, except where competition with sea or river or lake traffic, either alone or in combination with Railway transport, was concerned.

It appeared to be the case that the public had a right to appeal to the Inter-State Commerce Commission if any railway charged more for a shorter distance than for a greater one. This rule, as can be seen by study of the several Indian classifications, is, however, very frequently infringed in India, chiefly in cases of quotations *viâ* a junction is competitive through rates, and it is open to question whether the growing tendency to break the rule is to be recommended, and whether the public generally is a gainer thereby. The decision in America, however, so I was told, would not rest finally with the Commission, but could be taken to the higher Courts, where each case would be treated on its merits, and if good reasons for the discrimination were forthcoming, such as water competition and competition to "common" points on the seaboard, the action of the railways in departing from the differential rule would be upheld.

I understand, however, that for traffic within a State where no water competition existed, the differential rule was generally observed, but definite information on the subject was difficult to obtain, and I was told that there was still a great deal of unfair discrimination secretly going on.

228. The following instances of breaches of the differential rule were given me by a merchant at Denver, the cause being attributed to competition either wholly or partly with lake and ocean rates:—

Rate for steel plates, Chicago or Cleveland or Pittsburg, to San Francisco, 75 cents per 100 lbs., versus Pittsburg to Denver, 90½ cents.

Rate for structural material, Chicago to Salt Lake, 80 cents, versus Chicago to Denver, 77 cents.

Rate for steel plates, Chicago to Spokane, 110 cents, versus rate to Seattle, a coast port 280 miles further on, 75 cents.

I noticed that American railways did not quote fares other than Pullman's, nor did the ordinary tickets show their cost, but Americans did not seem to think this mattered.

Interchange of Stock Rules.

229. American railways generally charge each other 3 cents a mile for the use of a passenger vehicle and $\frac{6}{10}$ ths of a cent per mile per car for a goods vehicle. Their rules are somewhat crude and ineffectual, cars being wrongly diverted and in some cases kept off the home line for years, and the operating officials seemed desirous of altering them and adopting the Indian rule under which the charge is based on the carrying capacity of the wagon used. They were also most anxious to adopt a standard-sized car.

230. The proceedings of the semi-annual meeting of the Railway Association which I attended, are submitted (as Appendix d.), and the resolution proposing the adoption of a standard-sized car would have been almost unanimously adopted had not the Committee which drafted the rule suggested that action should be deferred for six months in order to allow all the railways to fully consider the proposals and give time for suggesting amendments. At the Guild dinner of the Association at which the President of the Inter-State Commerce Commission and myself were the only invited guests, I had to give a short description ofthe leading features of Indian railway working, and the members present showed a strong desire in favour of adopting the basis of carrying capacity in lieu of car for charge, and they seemed to think highly of the penalty rule under which Indian railways charge four times the ordinary time charge for detentions, and insist on vehicles being returned by the original route.

231. The "standard" car proposed for adoption is to be 36 ft. x $8\frac{1}{2}$ ft. x $7\frac{1}{2}$ ft. inside dimension. The width outside comes to $9\frac{1}{2}$ feet, and the reason given for making the dimension six inches less than the ordinary width of a passenger coach was on account of some of the terminal tracks having 11 feet centres. One or two of the members seemed inclined to agree with me, that it would have been more "American" to alter the limiting dimensions of the terminal plant and sidings, and have a 10 feet wide vehicle, as is the width of many of the 100,000 lbs. pressed steel coal and ore cars, than to lose six inches in width for all time, and it is instructive to note how the Americans—far-seeing as they areare getting tied up by past mistakes.

232. The most important principles of the new rule proposed were :—

1st. That there should be no pecuniary advantage to any interest arising from the use of cars larger or smaller than the "unit" car, and

2nd. That a premium should be placed upon compact and economical stowage.

233. Great importance was attached to the advantages of Institutions such as the American Railway Association, and it is to be congratulated on its success in having absorbed in its membership nineteen-twentieths of the total mileage of the American roads, including also the principal roads in Canada. This body has succeeded, just as our Indian Railway Conferences have done, in introducing much harmony and uniformity amongst rival roads, and its meetings are attended by the most influential men from all parts of the United States.

Postal Service.

234. The terms are practically the same as in India, the basis being a payment by weight of mail matter carried arrived at by occasional weighments. When a postal car is required it is furnished by the railways concerned, and an additional haulage charge is then made. The cars are fitted up like those in India.

Telephones.

235. They are universally used in America, and every American seems to live with his ears and mouth up against an instrument. Telephone messages are daily sent distances of 1,500 miles, and every good hotel has a telephone in each room where you can be switched on to any place within 1,500 miles of your room.

Suburban Traffic.

236. I inspected the suburban line of the Illinois Central Railway running out of Chicago. The Van Buren Station of this service is very handsome and beautifully clean. Two tracks are reserved for express service and two for local service. The former service does a distance of 14 miles in 33 minutes with 13 stops, the train sometimes running 40 to 50 miles an hour between stations. The fare is 15 miles for 15 cents. All trains are worked on the Hull electric automatic block system and the service is said to be the best in America.

Roller Bearings.

237. These have been tried for carriages and wagons on the N. Y. C. R.R. and are said to cost $ 12 per car, but they have not been tried on goods vechicles The Locomotive Department consider they save flange wear on curves and many passenger coaches are being fitted with them.

The B. &. O. R. have also given them a trial for some 12 months past, but at present they are unable to report the result. The B. and O. R. R. Locomotive Superintendent told me th-y had tried them under a few coaches, but that although they effected a saving in haulage the bearings were apt to break and go to pieces easily.

Electric Traction.

238. I inspected the system in force on the B. &. O. R. R. which has been designed to do away with the smoke nuisance in the tunnel through which all the B. & O. R. R. traffic passes going from south to north. The electric engine picks up all north bound trains at the South Station (Camden) and hauls all passengers and freight trains with their engines some two miles up a grade to Mount Royal Station. It also runs round all freight trains at this latter station and pushes them on to Waverly Station a mile or two further on. On the down-hill journey no steam is given to the engine, and no smoke is emitted, and the electric engine is therefore not required. The system is fully described in Paper 19 of the International Railway Congress which I attach (as Appendix c). The engine which weighs nearly 97 tons runs on the ordinary track, but the overhead trolley system, described in the paper, is now being replaced by a third rail. The voltage used is 750, but there is a transformer or " booster " capable of adding another 250 volts if required. The engine, which is rated at 1,000 h. p, has a motor mounted directly on each of its four axles, and I was told it often draws 1,200 gross ton trains in addition to the weight of any steam engines attached to the latter, and I was informed that the locomotive worked most satisfactorily, and that it hauled a ton of freight as cheaply as a steam locomotive could. The severest grade between Camden and Waverly stations is 85 feet to the mile, and on this grade the speed is 10 miles an hour whilst on the level it is 15 miles.

239. I did the trip between Buffalo and Niagara in an electric tramcar, the roadway being just like that of an ordinary steam railway. There was one car with overhead trolley, and we did the run, 22 miles, in 1 hour and 20 minutes, with frequent stops in

in the suburbs of Buffalo. When we got away from the suburbs, we ran sometimes 20 miles an hour quite steadily. It was exactly the same on the Washington-Mount Vernon trip, a distance of nine miles, the trains there consisting of two cars. A similar service is also run from Niagara on the left bank past the Rapids, the grades and curves being steep and sharp. Tramcar lines cover every portion of American towns, the overhead trolley system being generally adopted, at any rate at first, except in very big cities. They give a most convenient service with a universal fare of five cents. for any distance, which I think is too high, but they cannot be considered a perfect success until the dreadfully loud moaning noise caused by the motors and the noise made in tumbling over crossings have been done away with.

240. At Altoona I went a round trip to a park and back, about 10 miles, for 10 cents. in about 45 minutes. The system was overhead trolley and the grades were steep and curves sharp and the stops were numerous.

At Philadelphia I went round Fairmount Park on an electric railway. The road bed and track were solid, just like an ordinary railway with rails about 40 or 50 lbs. to the yard, and ballast of cinders; there were numerous well built over-bridges and tunnels, and there were sharp curves and very steep grades, and half the distance was double track. The distance was about eight miles with 14 stations, and the time taken was 30 minutes, the fare being five cents only. The system was overhead trolley, the current being hired from an electric power company. There was one car with an electric brake on it, and the car operated the treadles of the Hall electric automatic system of signals, putting them to danger after it passed the treadle, the line being divided into short block sections.

241. The N. Y. N. H. & H. R. R., as detailed in Paper 19, read at the last Paris Congress, in which all details as well as illustrations of the road and cars and motors are given (Appendix e.), has many electric railways, some of their branch lines having had electric substituted for steam traction. The best as described to me was the Providence and Fall River 18 miles section, with overhead trolley system. Each car, three of which generally form a train, weighs 34,000 lbs., and one is fitted on each of its four axles with geared motors. The voltage employed is 600, there being one power station in the centre and two battery accumlator stations, one at each end. The accumulators, which are charged from the power station, help to keep up the voltage, the current flowing from them when required into the line, this being required when several trains are on a section at one time. The fare is a little over one cent. a mile, or 25 cents. for 18 miles, and the run with 15 stops takes 50 minutes. The brake is Westinghouse, the air being compressed by electric pumps on the cars. Each car seats about 40 persons.

242. I made a most interesting trip on the Nantasket Branch Electric Railway (*see* Paris Congress Paper No. 19) with the General Superintendent of the N. Y. N. H. & H. R. R. We went by boat across Boston Harbour and then returned to Boston South Station by railway. The first 15 miles was from Pemberton to Baintree by electric train. This is an old steam railway line of 75 and 100 lb. section rail, the first half of it being worked by overhead trolley and the second half by a third rail. The third rail is not applied to the first section, simply because, on account of the danger attending the use of such a rail, it would mean fencing the line and spoiling the promenade on the beach on which it is laid. The third rails on the second portion consist of two rails of about 100 lbs. weight each, each of them being used for conveying the current, all the 15 miles being a double track road. At the Baintree end the third rails are aided by a feeder conductor. The power house is in the centre, and ordinary steam railway carriages from the main line of the N. Y. N. H. & H. R. R. are hauled over the road, five such cars being

drawn by a similar carriage fitted with four motors. Such a train is shown in the photograph (marked Appendix f.), attached to this report. Open and covered tram-type cars, about 48 feet in length over bodies, are also used, sitting 108 in the trailers and 96 in the motor vehicles. Some of the motor cars weigh from 33 to 48½ tons, depending on whether they carry two or four motors each. The latter are rated at 700 horse-power.

With one car we did the first run of $5\frac{85}{100}$ miles in seven minutes, the second timed run of eight miles being done in 14 minutes.

The voltage employed was 680, and the General Superintendent told me he had often travelled on the straight at 60 miles an hour. The railroad crosses many roads on the level, and speed has to be reduced. Ordinary railway freight cars are also handled by the motor cars, which have the motors geared to, but not concentric with, the axles. The boilers in the power house are fuelled with sparks collected from the extension ends of steam locomotives. The Railway officials assured me that it was cheaper to work a service by electricty than by steam, whenever frequency of trains was essential to the service, as is the case here. The current is only used when required, and it is more economical to work short and frequent trains by electricty than by steam engines. The fare was one cent a mile.

243. Another instance of up-to-date electric traction is found at Boston. Here the cars from one portion of the city converge into a subway about a mile long, and from this they emerge and spread out again over the city and suburbs. The system is overhead trolley, and it is a strange sight to see a constant stream of brightly lit cars bound for different places following one another quickly through the electric-lit tunnel, in which of course there are stations to serve the central section of the city. Here again, however, as is the case everywhere in America with electrically worked vehicles, the noise is deafening and most unpleasant, and I feel certain in time a remedy for this defect will have to be found.

244. From Cleveland to Akron also there is a suburban electric railway service. The distance is 36 miles, with about 20 stops, and this distance is run in 1 hour and 40 minutes. The single fare is 50 cents, and the return fare 75 cents.

245. It is probable that electric tramways could be advantageously employed in India, and in the country I can see little objection to the overhead trolley system. In towns even, as is the case in Glasgow, overhead wires could be installed without spoiling the appearance of the streets. Light goods could be worked as well as passenger trains. It is foolish to prophesy, but it is quite possible the next generation may not know what a steam locomotive is. A perusal of Paris Congress Paper 19 will reveal the enormous strides made in electric tractions in America in ten years, during which time 16,000 miles of electric railways were constructed.

Railway Books of Reference, etc.

246. I submit (as Appendix g.) the "Official Railway Equipment Register" given me by the American Railway Association. It contains much interesting information, including the rules for loading freight cars, moving and loading dimensions of cars, inside and outside dimensions and capacity of all cars. It also includes the rules governing the condition of and repairs to passenger equipment cars and freight cars exchanged between companies and gives a list of railway and car owning companies that have subscribed to the rules.

247. From a study of the book it appears that the outside width of freight cars on the

leading double track lines is as follows: N. Y. C. & H. R. R. 9 ft. 4¾ ins. to 9 ft. 6 ins.; Lake Shore & Southern Michigan R. R. 10 ft.; C. & N. W. R. R. 9 ft. 11½ ins.; B. & O. 9 ft. 7 ins. to 9 ft. 8 ins.; P. R. R. 9 ft. 4¾ ins.; and for their pressed steel ore and coal cars 9 ft. 6 ins.

The loading dimensions of most of their lines is as follows: width P. R. R. 10 ft., N. Y. N. H. & H. R. R. 10 ft. 3 ins.; N. Y. C. & H. R. R. 10 ft. 6 ins.; whilst single track lines go to very much greater widths than this. I also submit (as Appendix g.) the Association's "Train Rules," Car Service Rules," "Interlocking Rules," "Block Signal Rules" and "Diagrams of Signals" book.

248. Minutes of meetings of the New York and New England Railway Clubs are also furnished (as Appendix h. and X.) and I attended a crowded meeting of the first club soon after my arrival in New York. These books are interesting as showing the tendency there is amongst American railway men to meet and discuss railway matters, and it may be partly due to this that their views are so wide and their methods so bold. The first paper is also well worth studying because it contains a very good description of the different pneumatic tools and the uses to which they are put in railway work, and it foretells very wide and extensive uses of air power in connection with railway workshops and factories. In the New England Club Minutes there is an interesting paper on brakes entitled "Parting of Trains and Skidded wheels."

American Specifications for Iron and Steel.

249. I trust I may be excused in drawing attention to the Review of the American Standard Specifications, Test Pieces; and Methods of Testing Iron and Steel, of which I attach a copy (as Appendix i.). It is not within my province to criticise the British methods of manufacturing railway material, and I certainly think India has little to complain of in respect of the manner in which the Consulting Engineers for Indian Railways do their work at home, but if our trade is going from us I think it is partly because we do not adopt such good business-like methods as the Americans.

The Review shows the practical methods adopted by Americans, and how designers, manufacturers, and buyers all work together, and how all unnecessary differences, details and hindrances to business are eliminated, thereby enabling Americans to produce the same or an equally serviceable article at less cost than other people.

What the Americans aim at is the production of an article, of which they adopt the best thought-out type, at the lowest profitable price, which will pass certain physical and chemical tests, but about the details of manufacture of which they leave the makers a perfectly free hand, and when British designers and manufacturers follow their example I believe Indian Railways will not have to give orders to foreign firms. That the American designs of bridges, although few in number, are in no way inferior to those of other countries; Mr. Robertson, late of the Indian Railway Department, in a lecture lately delivered at Chatham, gives ample proof.

Concluding Remarks.

250. My notes are chiefly confined to bringing into prominence the remarkable heavy trains, heavy wagons, and heavy engines used in America, as also the successful and rapid way in which Americans transfer coal from wagons to ships, and *vice versâ*, and save manual labour, especially in fuelling engines. They also emphasise the fact that the best American railways find a heavy rail and a plentiful supply of good stone or gravel ballast is the cheapest thing in the long run. They also bring to notice the rapid spread of electric traction and pneumatic and electric power, and the substitution in large

stations of air and electricity as the power for controlling interlocking points and signals in place of the ordinary mechanical systems.

Another great improvement that is being rapidly extended is the use in congested places of automatic block signalling, where trains signal themselves.

251. In giving such facts as I could collect (and I took considerable trouble to get them and verify them) I trust that Government will not consider that I under-rate the merits of Indian railways and over-value those of America. Such is far from my intention, for, on the contrary, I consider our road beds are so strong and good and finished that there is nothing, so I believe, that should prevent us from adopting the best of the American methods. With the roads we possess, and with a stronger track and the cheap labour available in India, I am convinced that, if we will only try the big engines and large capacity wagons and huge trains, we shall come to adopt them permanently, and when we do, India will have far and away the best and cheapest worked railways in the world.

252. To support my recommendations I would draw attention to Mr. W. R. S. Jones' (late of the Public Works Department of India) Memorandum on Improved Rolling Stock which I submit (as Appendix i). This document is interesting in showing the author's views on the great advantage to be gained by using the best stock, what financial results would result from following such practice, and how all-important he considers it to be to spend any amount of money in removing restrictions to its use. I was much struck with the author's views at the time I was Deputy Manager of the N. W. Railway, and I then suggested trials being made with the stock proposed by Mr. W. R. S. Jones. I can only say from what I have since seen in America, that the pamphlet exemplifies American practice, only the Americans have gone beyond the author's limitations, as he showed a design for an E. I. R. R. bogie coal wagon weighing 10·75, and carrying 37·25 tons, whereas we now have thousands of coal and ore wagons in America weighing 15 and carrying 50 tons. Mr. Jones' design was, however, based on a six-ton wheel load, whilst American practice works out to 8·09 tons per wheel, and as previously pointed out, these American loads are hauled over roads and bridges no stronger than Indian ones, and the American gauge is 9½ inches smaller than the Indian one. Mr. Jones in his concluding remarks says that there is no subject so important as that of rolling special stock, and he argues that all engineering obstacles prejudicial to its improvement should be removed without a moment's hesitation, and he gives good reasons for showing that financially this is the right thing to do. I may say that I formed my opinions from the author's views many years before he wrote the memorandum, and everything I have since learnt convinces me that American practice, which is what he recommends, is the right one to follow. In short, it is more economical in railway working to fit the road to the stock, making the latter the very best possible, than to build the stock to suit the road.

253. I think many fair-minded men will agree with me that it is too often the case that other nations are too sceptical and critical of American notions, but they are a very practical and inventive race, all of them being engaged in work; they are devoid of conservatism and are very bold and progressive in their ideas, and they are always ready to reject the old, and try any new thing if there be a chance of making money in it.

254. The most foolish thing to do is to judge America by its newspapers, for there is so much exaggeration in them that it is difficult to separate truth from romance, and consequently American methods are at first often discredited, or received with incredulity; but I am sure that a visit to American railways and workshops will open the eyes of many railway men and get them out of the way of thinking that what they

see done on their own line is as good as can be done anywhere else. I myself remember the time when I had great doubts as to the accuracy of American newspaper statements to the effect that American goods trains weighed 2,000 tons, and I have been told by American railway men themselves, that if anyone had predicted 20 years ago that a goods train weighing 3,000 to 3,500 tons would be hauled by one engine, he would have been dubbed a lunatic, yet to-day it is an every-day occurrence on some lines, and the Americans deserve the greatest credit for showing the world how heavy an engine can run safely on an ordinary rail, and what an immense load such an-engine can haul.

W. V. CONSTABLE,
Lieutenant-Colonel Royal Engineers,
Manager, Eastern Bengal State Railway,
(On furlough).

London, 23rd July 1901.

INDEX TO APPENDICES.

A. Electro-pneumatic system of interlocking. Not printed, but all information can be obtained from the Westinghouse Company's Agents, Messrs. MacKenzie & Holland of London. The details will be embodied in a Technical Paper on the subject, which is under preparation.

B. Three copies of a book illustrating and describing the St. Louis Union Station placed in the Technical Section library, Public Works Secretariat. Plan of yard printed.

C. Annual report of, and arrival and departure of trains on, the Boston and Albany Railroad. Not printed.

D. Automatic Block signalling. Not printed. Information can be obtained from the Union Switch and Signal Company, Swissvale, Pennsylvania, United States of America, or the Westinghouse Company, London; and by reference to the International Congress Paper No. 25 of 1890. The details will be embodied in a Technical Paper on the subject, which is under preparation.

E. A suitable kind of glass for lenses of distant signals: specimen preserved in Technical Section.

F. Illustration of N. Y. C. Railway supported joint.

G. Plate showing evolution of splice bars.

H. Illustrated comparison of ordinary and Bonzano joints.

I. Illustrated comparison of bearing surfaces of cross ties on various railways.

J. A method of rendering a line dust proof by sprinkling the ballast with oil. Not printed. The Chief Engineer, P. R. R. at Philadelphia, could furnish information, whence copies of pamphlet might be obtained. The subject is also discussed in International Congress Paper No. 9 of 1890.

K. A dissertation on ballast. Not printed. *See* International Congress Paper No. 9 of 1890.

L. A photograph of a passenger locomotive. Not reproduced.

M. A diagram illustrating the composition of a passenger train. Not printed.

N. Illustrated description of pressed steel trucks. Not printed. All drawings and description of cars can be obtained from the Pressed Steel Car Company, of Pittsburg, Pennsylvania, United States of America. The English Agents are the Transportation Department Company, 6, St. Clement's Lane, Lombard Street, E.C. The Leeds Forge Company, of England, do similar sort of work.

O. Pamphlet and illustrations of steel castings. Not printed.

P. Short description with illustrations, of an acetylene generator for lighting passenger vehicles.

Q. A photograph of a freight engine. Not reproduced.

R. A pamphlet on classification of locomotives. Extracts referring to the two engines quoted in the Report are printed.

S. Tabulated engine ratings. Not printed. Placed in Technical Section library.

T. A collection of diagrams of types of locomotives, which has been filed in the Technical Section. Selected diagrams are printed.

U. Descriptive note and diagrams of four engines in use on the C. B. and Q. Railway.

V. Picture of the heaviest passenger engine, weighing 252,400 lbs. and a heavy goods engine.

W. Diagrams of types of locomotives.

X. An annual meeting of the New England Railroad Club. Not printed.

Y. A drawing of a coal wagon. Not printed.

Z. Economical size of goods trucks. Not printed. *See* International Congress Paper No. 18 of 1890.

a. Pamphlet entitled "Do American Railways pay?" Not printed.

b. General statement of the affairs of the N. Y., N. H. and H. Railroad Company. Not printed.

c. Twenty-third annual report of the Boston and Albany Railroad Company. Not printed.

d. Reports of committees of the American Railroad Association, April 1901. Not printed.

e. Report on Electric Traction. Not printed. *See* International Congress Paper No. 19 of 1890.

f. A photograph of an electric train. Not reproduced.

g. The official Railway Equipment register, April 1901, and 5 pamphlets of standard code rules. Not printed. Copies can be obtained from the Secretary and Treasurer, American Railway Association, 24, Park Place, New York.

h. Meeting of New York Railroad Club, March 1901. Not printed.

i. Review of American Standard Specifications. Not printed. Copies can be obtained from the same source as g.

j. Memorandum on pressed steel shapes *v* rolled sections for vehicle under-frames and bogie trucks. Not printed. Copies are with the Government of India.

APPENDIX P.

STANDARD ACETYLENE LIGHTING COMPANY,

174, STATE STREET (WASHBURN BUILDING),

SPRINGFIELD, MASS.

June 7th, 1901.

COL. CONSTABLE, R. E.

DEAR SIR,

Knowing that you are interested in lighting railway coaches with acetylene gas, we beg to call your attention to our system. First I will say that we have had one car on the B. & A. Railroad lighted for nine months, to the entire satisfaction of the Road. We have also had two trains equipped on the same road for a period of six months.

We enclose you blue prints of our device.* Our generator, the "Massasoit," is of the carbide feed displacement type. The carbide is fed from the carbide holder "A" into the generator "B" through the automatic valve and diaphragm "C"; this is governed by a spring and leather diaphragm. As the gas is taken from the generator "B," releasing the pressure therefrom, the valve is opened by the spring, dropping sufficient carbide into the generator "B" to cause the leather diaphragm to close the valve.

The pressure that we acquire on the generator is from 6 to 14 oz. Should there be by any means enough carbide dropped into the water to create over 1½ lbs. pressure, the excess of side pressure would pass off through the water columns "EE" to the atmosphere, thereby making it impossible to sustain over 1½ lbs. pressure to the square inch in the generator.

The service pipe "D" connecting with the three-way valve "F"; said valve controlled by a locking device from the top of carbide holder, where the carbide charge is placed in the machine and the cleaning-out device at the bottom, thereby making it impossible to recharge or discharge the machine when there is any gas in the generator, as when the machine is unlocked the service pipe is closed and the three-way valve open to the atmosphere. In the service pipe is the cleaner marked "G"; the gass passing through said cleaner, then through said regulator marked "H," thence through the pipe marked "I" into the bottom of the dryer marked "J." The cylinder marked "K" is an automatic device, relieving the pressure from the burners in case of the regulators becoming inoperative, also forming a drip for any condensation that is not taken by the cleaner. We never have any after generation; that is to say the instant we stop consuming the gas we stop generating. Through tests made on the B. & A. Road we find that we can light a coach with 300 candle power for 5 cents an hour.

Our system admits of the use of any modern oil lamp, with which coaches may be already equipped, by placing our gas tips in the old burners, thereby saving the expense of new lamps. We install our generator in the closet of the car. It requires 30" by 20" floor space. We can meet all of the requirements of the National Board of Underwriters, which is a big item to be considered in railway coach and station lighting.

Very respectfully yours,

T. B. PURVES, Jnr.

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* See three plates P. below.

APPENDIX R.

	PRESENT CLASSIFICATION.		E 2
1	Number of Pairs of Driving Wheels		2
2	Diameter of Driving Wheels		80″
3	Size of Driving Axle Journals		$\frac{9\frac{1}{2}''}{8\frac{1}{2}''}$D × 13″L
4	Length of Driving Wheel Base		7′ 5″
5	Total Wheel Base of Engine		30′ $9\frac{1}{2}$″
6	Total Wheel Base of Engine and Tender		53′ $9\frac{9}{16}$″
7	Number of Wheels in Engine Truck		4
8	Diameter of Wheels in Engine Truck		36″
9	Size of Engine Truck Axle Journals		$5\frac{1}{2}$″ × 10″
10	Spread of Cylinders		$85\frac{1}{2}$″
11	Size of Cylinders		$20\frac{1}{2}$″ × 26″
12	Steam Ports		$1\frac{1}{2}$″ × 20″
13	Exhaust Ports		3″ × 20″
14	Travel of Valve		7″
15	Lap of Valve		$1\frac{1}{2}$″
16	Type of Boiler		Belpaire. Wide Fire Box.
17	Minimum Internal Diameter Boiler		$65\frac{3}{8}$″
18	Number of Tubes		290
19	Outside Diameter of Tubes		2″
20	Length of Tubes between Tubes Sheets		180″
21	Fire Area through Tubes	sq. ft.	5·10
22	Size of Fire Box, inside		66″ × 111″
23	Fire Grate Area	sq. ft.	50·8
24	External Heating Surface of Tubes	sq. ft.	2278·0
25	Heating Surface of Fire Box	sq. ft.	152
26	Total Heating Surface of Boiler	sq. ft.	2430
27	Steam Pressure per square inch	lbs.	185
28	Number of Wheels under Tender		6
29	Diameter of Wheels under Tender		42″
30	Size of Tender Truck Axle Journals		5″ × 9″
31	Weight of Engine Empty	lbs.	150500
32	Weight of Truck in Working Order	lbs.	36335
33	Weight on 1st pair of Drivers	lbs.	49590
34	Weight on 2nd pair of Drivers	lbs.	51105
35	Weight on Trailing Wheels	lbs.	32320
36	... ...		......
37	Weight of Engine in Working Order	lbs.	169350
38	Weight of Tender Loaded	lbs.	90000
39	Ratio of Heating Surface to Grate Surface	lbs.	47·8
40	Ratio of External Flue Heating Surface to Fire Box Heating Surface		14·9
41	Tractive Power per lb. of M.E. Pressure		136·6
42	Tractive Power with M.E. Pressure equal to $\frac{4}{5}$ of Boiler Pressure...		20220
43	Diameter of Trailing Wheels		50″
44	Size of Trailing Axle Journal		7″ × $11\frac{3}{4}$″

APPENDIX R.

PRESENT CLASSIFICATION. H 5

1	Number of pairs of Driving Wheels		4
2	Diameter of Driving Wheels		56"
3	Size of Driving Axle Journals		9"D x 13"L
4	Length of Driving Wheel Base		17' 6"
5	Total Wheel Base of Engine		25' 11½"
6	Total Wheel Base of Engine and Tender		55'(9"
7	Number of Wheels in Engine Truck		2
8	Diameter of Wheels in Engine Truck		30'
9	Size of Engine Truck Axle Journals		5½" x 10"
10	Spread of Cylinders		90"
11	Size of Cylinders		23½" x 28"
12	Steam Ports		1½" x 21"
13	Exhaust Ports		3" x 21"
14	Travel of Valve		6"
15	Lap of Valve		1"
16	Type of Boiler		Belpaire.
17	Minimum Internal Diameter Boiler		69½"
18	Number of Tubes		369
19	Outside Diameter of Tubes		2"
20	Length of Tubes between Tube Sheets		168"
21	Fire Area through tubes	sq. ft.	6·36
22	Size of Fire Box, inside		40" x 120"
23	Fire Grate Area	sq. ft.	33'33
24	External Heating Surface of Tubes	sq. ft	2720·00
25	Heating surface of Fire Box	sq. ft.	197·00
26	Total Heating Surface of Boiler	sq. ft.	2917·00
27	Steam Pressure per square inch	lbs.	185
28	Number of Wheels under Tender		8
29	Diameter of Wheels under Tender		33"
30	Size of Tender Truck Axle Journals		5" x 9"
31	Weight of Engine Empty	lbs.	173100
32	Weight of Truck in Working Order	lbs.	20800
33	Weight on 1st pair of Drivers	lbs.	41600
34	Weight on 2nd pair of Drivers	lbs.	43000
35	Weight on 3rd pair of Drivers	lbs.	45600
36	Weight on 4th pair of Drivers	lbs.	45500
37	Weight of Engine in Working Order	lbs.	196500
38	Weight of Tender Loaded	lbs.	100600
39	Ratio of Heating Surface to Grate Surface		87·5
40	Ratio of External Flue heating Surface to Fire Box Heating surface		13·8
41	Tractive Power per lb. of M. E. Pressure		276·1
42	Tractive Power with M. E. Pressure equal to ⅘ of Boiler Pressure		40860

APPENDIX U.

CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY.

CHICAGO.

MAY 7TH 1901.

DEAR SIR,

I now enclose diagrams of our D-3, G-3, R-2 and P-1 Engines.*

The D-3 engines were designed about three years ago for heavy service in the Black Hills. They are giving very satisfactory service, although if we were to design other engines of the same type, we should probably use a radial stay fire box about 5½′ wide and 8′ long and increase the boiler pressure to 200 lbs. and the diameter of the boiler to about 76″. It might also be thought best to increase the diameter of the drivers from 52″ to 58″.

The G-3 engine was designed about two years ago. We now have eight of these engines in switching service and are building four more at our works in Aurora. We find them to be very satisfactory.

We built the first four engines of the class R type last year, and found them to be in most respects, very satisfactory for freight service. The class R-2 engines are the result of our experience with the class R-1 engines and they have larger cylinders, larger boilers, and more heating surface. We have ordered sixty class R-2 engines and have now received the first order of thirty, but have not yet had them in service long enough to enable us to say anything in regard to their performance.

The class P-1 engine is the design of the Baldwin Locomotive Works, and is doing excellent work in passenger service. We have five of these engines, two with the six wheel tenders shown on the diagram and three of more recent construction with four wheel swivelling trucks and tanks like those used behind the class R-2 engines. If we were to build any more of these engines we should probably get them with a fire box about 5′ wide and 7½′ or 8′ long. We should also try to increase the heating surface.

Yours truly,

F. H. CLARK,

Mechanical Engineer.

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* See plate U. below.

G. C. Press, Simla.—No. 1876 P. W. D.—7-1-03.—750.